Heightened Sensitivity to Improbable Catastrophes as a Pathogenic Marker of Obsessive-Compulsive Disorder: Theory and Experimental Evidence

A Dissertation

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Dedication

To Anabel, Nathan, and our newest addition,

whom we look forward to meeting very soon

Abstract

Although the obsessions implicated in obsessive compulsive disorder (OCD) could theoretically involve any distressing topic, they typically gravitate toward a handful of specific themes (e.g., contamination, religion, sex, etc.). The universality of these themes across OCD patients from different time periods, cultures, and age-groups suggests they are manifestations ofa common, underlying process, but little effort has been made to elucidate the identity of this process. One intriguing feature shared across most common obsessions is a heightened concern with consequences that are objectively terrible but highly unlikely (e.g., catching HIV from a doorknob, being sent to hell for a fleeting immoral thought). The ubiquity of this particular consequence suggests that OCD may be characterized by an underlying sensitivity to improbable catastrophes (SIC), but this possibility has yet to be explored. The present dissertation sought to address this gap by examining whether OCD symptoms predicted higher anxious reactivity toward unlikely, highly aversive threats across three experimental studies. In the first study, college students with higher OCD symptoms exhibited greater avoidance of improbable, highly aversive threats, as well as greater expectancy and physiological reactivity for improbable threatsin general. An extension of this investigation with different types of experimental threats (study two) showed that OCD symptoms predicted heightened expectancy of improbable threats involving both harmful and disgust-related consequences, while relations between OCD symptoms and avoidance of improbable, highly aversive consequences were specific to

harmful threats. Finally, study three showed that differences in expectancy, anxiety, and avoidance for improbable threats prospectively predicted changes in OCD symptoms over the first year of college, with indices of anxious reactivity to improbable threat (anxiety, startle, avoidance) emerging as especially predictive among participants who rated the threat as highly aversive. Together, these studies implicate SIC as a novel pathogenic marker of OCD and suggest its role in the illness may derive from a more general tendency to overestimate the likelihood of improbable outcomes bearing high subjective costs.

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Chapter 1: The Role of Improbable Catastrophes in OCD

Obsessive-compulsive disorder is a well-known psychiatric condition, defined by either obsessions, compulsions, or both (American Psychiatric Association [APA], 2013). Obsessions are recurrent and persistent thoughts, urges, impulses, or ideas that a) are experienced as intrusive and unwanted, b) typically provoke distress or anxiety, and c) the sufferer tries to ignore, suppress, or neutralize with them some other thought or action. Compulsions are repetitive, time-consuming behaviors (e.g., handwashing) or mental acts (e.g., counting) that thesufferer feels they must perform in response to the obsession or according to rigid rules.

Although compulsions are aimed at reducing anxiety or distress, or to prevent some dreaded event, they are not connected to such events in a realistic way, or are clearly excessive (APA, 2013). However, because compulsions provide temporary relief of distress, they are reinforced and thus become more likely to be re-enacted in the future (Taylor, 2009). The functional impactof these symptoms, moreover, is often debilitating: OCD is associated with significant social, educational, and occupational impairment and reduced quality of life (Huppert, Simpson, Nissensen, Liebowitz, & Foa, 2009) and is believed to be the 10th largest source of disability in the developed world (Lopez & Murray, 1998).

Characteristics of OCD

Epidemiology and Demographics

OCD has estimated 12-month and lifetime prevalence rates of 2.5% and

1.2%, respectively (Ruscio, Stein, Chiu, Ressler, 2010; Kessler, Petukhova, Sampson, Zaslavsy, & Wittchen, 2012). Among those with OCD, 96% have both obsessions and compulsions, 2% haveonly obsessions, and 2% have only compulsions (Foa & Kozak, 1995). Sub-clinical OCD symptoms are even more common, as 25% of the population is estimated to experience least one OCD obsession or one OCD compulsion over a 12-month period (Stein, Forde, Anderson, &Walker, 1997).

OCD is most likely to emerge in early 20s (Rasmussen and Eisen, 1992), though its meanage-of-onset may be as late as mid 30s in some countries (Weissman, 1998). Other work suggests OCD's age-of-onset is bimodal, peaking at approximately 11 years of age and again at around 23 years of age (Delorme et al., 2003). These different age-of-onset classes also possess divergent clinical correlates (e.g., Tukël et al., 2005), indicating they may be distinct OCD subtypes (Chabane et al., 2005). Regardless of when it develops, OCD tends to be chronic (Rasmussen & Tuang, 1986), though some may experience a more episodic course (Skoog & Skoog, 1999), or progressively worsening symptoms over time (Goodwin et al., 1969).

OCD is slightly more prevalent in females than males (Rasmussen and Eisen, 1992). However early-onset OCD is more common among males (Riddle et al. 1990; Leckman et al., 1997), who comprise approximately 70% of such cases (Swedo, Rapoport, Leonard, Lenane, & Cheslow, 1989). OCD is slightly less common among black individuals, but the effect does not appear to be specific to OCD and may be the result of reduced service

utilization/delivery (Rasmussen & Eisen, 1992). Overall, the demographic (e.g., gender) and clinical features (e.g., course) of OCD appear to be quite consistent across cultures (Fontenelle, Mendlowicz, Marques,Versiani, 2004).

Comorbidity patterns

Between 45 - 55% of individuals with OCD have a concurrent comorbid psychiatric condition, while approximately 78% have a lifetime comorbid psychiatric condition (Hofmeijer-Sevink et al., 2013; Dennys, Tenney, van Megen, Geus, & Westenberg, 2004). Among OCD- related conditions, OCD is most commonly comorbid with tic disorder (12.5%) and body dysmorphic disorder (8.7%); among anxiety-related conditions, OCD is most commonly comorbid with social anxiety disorder (14%) and generalized anxiety disorder (13%; Lochner et al., 2014). Additionally, 25% of OCD patients meet criteria for hoarding disorder, which was recently recognized as a separate condition (Wheaton, Timpano, Lasalle-Ricci, Murphy, 2008), and approximately 20% of individuals with OCD meet criteria for major depressive disorder (Dennys et al., 2004), though some studies estimate the proportion to be as high as one-third (Overbeek, Schruers, Vermette, & Griez, 2002). A smaller but significant proportion of OCD patients also meet criteria for eating disorders (11.3%; Sallet et al., 2010), substance use disorder(4.3%), and psychotic-spectrum conditions (3.3%; Denys et al., 2004). Finally, approximately 25% of OCD patients meet criteria for obsessive-compulsive personality disorder (Coles, Pinto, Mancebo, Rasmussen, & Eisen, 2008).

In virtually all cases, OCD develops after rather than before its

comorbid mental disorder (Ruscio et al., 2010). The exceptions to this are separation anxiety disorder, which usually develops before OCD, and PTSD, which typically develops in the same year (Ruscio et al., 2010).

Treatment

Like many mental illnesses, OCD is usually addressed through a combination of psychological and pharmacological treatments. For psychological treatment, the intervention with the strongest empirical support is Exposure with Response Prevention Treatment (EX/RP), which involves exposing patients to gradually more distressing obsession-provoking scenarios while simultaneously preventing compulsions (National Collaborating Centre for Mental Health,2006). EX/RP has consistently demonstrated large effect sizes when it comes to reducing OCD symptoms relative to waitlist control treatments (Christensen, Hadzi-Pavlovic, & Mattic, 1987) and active control treatments (e.g., relaxation techniques; Abramowitz, 1997). Cognitive therapy (CT), which involves addressing maladaptive beliefs such as the importance of controlling thoughts, has been found to be equally effective as EX/RP (Rosa-Alcàzar, 2008; Olatunji, Davis,Powers, & Smits, 2013). Meta-analytic work also suggests that both treatments are significantly more effective in treating OCD in children compared to adults (Olatunji et al., 2013).

Regarding psychiatric medication, OCD is most commonly treated with Selective Serotonin Reuptake Inhibitors (SSRIs), which have consistently outperformed placebo controls in reducing OCD symptoms (Soomro, Altmna, Rajagopal, & Browne, 2008). There is also evidence that higher doses of SSRIs

are associated with greater symptom reduction, though they have also been shown to result in a higher treatment dropout rate (Bloch, McGuire, Landeros-Weisenberger, Leckman, & Pittenger, 2010). SSRIs do not appear to facilitate a greater reductionin OCD symptoms beyond psychological treatment, but they have been shown to significantly reduce depression symptoms in OCD patients beyond psychological treatment (O'Connor et al., 2006).

Though SSRIs, CT, and EX/RP have been associated with large effect sizes in the treatment of OCD, they nonetheless remain ineffective in many cases. For SSRI treatment, up to40-60% of OCD clients do not have a satisfactory outcome with SSRIs (Pigott & Seay, 1999; Jenike & Rauch, 1994). For EX/RP and CT, only 40-50% of OCD clients show a significant decrease in symptoms and only 25% experience total remission (Fisher & Wells, 2005).

Biological Correlates

Traditionally, OCD is believed to arise from disruption in the cortico-striatal-thalamiccircuit (CSTC), based on findings showing abnormal metabolic activity in the orbitofrontal cortex, anterior cingulate/caudal medial prefrontal cortex, and the caudate nucleus (Saxena, Brody, Schwartz, & Baxter, 1998). Additionally, this network tends to show increased activity both "at rest" and during symptom provocation among OCD patients, as well reduced activity following treatment (Graybiel & Rauch, 2000). Functionally, this circuit has been implicated in the formation of habits, suggesting its excessive activation could facilitate highly repetitive thoughts (obsessions) and actions

(compulsions) that the person has difficulty stopping (Graybiel, 1997). Indeed, stimulation of the CSTC circuit in rodents produces OCD-like habitual behaviors like repetitive grooming, which eventually become independent of stimulation and areeffectively reduced using SSRIs (Ahmari et al., 2013). However, more recent neurobiological models of OCD implicate the amygdala and hippocampus as modulators the CSTC, perhaps explaining why anxiety is often coincident with obsessional thoughts (Milad & Rauch, 2012)

Like most mental illnesses, OCD tends to be quite heritable. Twin studies estimate OCD's heritability to be between 27-47% for adult cases and 45-65% for child cases (Pauls, 2008), with potentially higher heritability rates for obsessions relative to compulsions (Jonnal, Gardner, Prescott, & Kendler, 2000). The heritability of OCD has also been demonstrated in family studies, where its prevalence is approximately 12% among relatives of OCD probands (Pauls, Alsobrook, Goodman, Rasmussen, & Leckman, 1995). There is also strong evidence that OCD involves at least one major susceptibility locus for both adult-onset and child-onset cases, which has higher penetrance in females (Grados, Walkup, & Walford, 2003). Genetic associationstudies have also found links between OCD and genes commonly implicated in many mental illnesses such as the serotonin transport genes (5-HTTLPR), serotonin receptor genes (5HT1-D beta; 5HT2A), and the low-activity allele of the catechol-methyltransferase heterozygous genotype (COMT; Nestadt, Grados, & Samuels, 2010). Notably, OCD does not appear to be any more heritable than other anxiety-related conditions (Hettema, Neale, & Kendler, 2001).

Symptom presentations

Although technically a unitary construct, OCD is known to exhibit several distinct symptom presentations (Rasmussen & Eisen, 1992). Common obsessions include: Concerns withcontacting germs, dirt, or disease (contamination); fears of bringing about a disaster for failing tocheck something thoroughly or completely (pathological doubting); concerns with properly following religious or moral rules (scrupulosity); concerns with acting on some hidden aggressive impulse (aggressive OCD); concerns with possessing and/or acting upon a secret sexual desire that is discrepant from one's perceived sexual identity (sexual OCD); an immoderate focus on one's bodily functions or appearance, including their potential malfunctions and abnormalities (somatic OCD); and an excessive preoccupation with order, symmetry, exactness, and organization, particularly regarding one's possessions or environment (symmetry). Not surprisingly, some of the most common compulsions are those that are thematically linked to common obsessions, for instance: repeated handwashing or cleaning (washing/cleaning) for contamination obsessions; repeatedly checking measures necessary for preventing disaster (checking) for pathological doubting; and repeatedly lining up, straightening,or organizing personal objects (ordering) for symmetry obsessions. However, there are other common compulsions that are not explicitly tied to particular obsessions, including repeating certain trivial actions, phrases, or behaviors (repeating) and counting up to certain numbers (counting).

Research on specific OCD presentations has typically focused on elucidating their differences (McKay et al., 2004). First, there is fairly compelling evidence that certain presentations co-occur with each other more commonly, suggesting etiological divergence. For instance, in a meta-analysis of 21 factor analytic studies of OCD symptom presentations (N = 5124 OCD patients), Bloch, Landeros-Weisenberger, Rosario, Pittenger, & Leckman (2008) found a four-factor solution explained 79% of the variance in OCD symptom heterogeneity: A symmetry factor composed of symmetry obsessions and repeating, ordering, and counting compulsions; a forbidden thoughts factor, composed of aggressive, sexual, religious, and somatic obsessions and checking compulsions; a cleaning factor, composed of contamination obsessions and cleaning/washing compulsions; and a hoarding factor, composed of hoarding obsessions andhoarding compulsions.

Further support for the heterogeneous nature of OCD comes from studies showing that itssymptom dimensions exhibit divergent clinical correlates. For instance, hoarding consistently demonstrates a poorer response to psychological and pharmacological treatments (Mataix-Cols, Marks, Greist, Kobak, & Baer 2002; Abramowitz, Franklin, Schwartz, & Furr, 2003; Stein, Andersen & Overo, 2007), as do sexual obsessions and religious obsessions in some studies (Mataix-Cols et al. 2002; Alonso, Menchon, & Pifarre, 2001; Shetti, Reddy, Kandavel, 2005; though see Mataix-Cols, Rauch, Manzo, Jenike, & Baer, 1999; Stein, Andersen, & Overo, 2007).OCD symptom dimensions may also involve different psychiatric comorbidities (Hasler et al.,

2005). For instance, the forbidden thoughts factor has been broadly associated with higher risk ofanxiety and mood pathology (e.g., generalized anxiety disorder, depression, panic disorder, social phobia) as well as alcohol abuse; the symmetry/ordering factor has been associated with elevated risk of agoraphobia specifically; and the cleaning factor has been associated with elevated risk of eating disorders (Hasler et al., 2005). Additionally, the symmetry/ordering and hoarding symptoms are consistently more prevalent among those with comorbid obsessive compulsive personality disorder (e.g. Coles et al., 2008; Lochner et al., 2011). Finally, there is also compelling evidence from a large sample of OCD patients ($N = 955$) that the symmetry dimension is associated with an earlier age of onset than the other dimensions and that individuals with higher levels of the forbidden thoughts factor are more likely to evidence awaxing-waning symptom course (Kichuk et al., 2013).

In addition to exhibiting divergent clinical correlates, there is also evidence that OCD symptom presentations possess distinct neurobiological profiles. Much of the early evidence for this assertion came from neuropsychological studies. For instance, individuals with primary aggressive/checking symptoms have shown worse performance on trail-making tests (Hashimotoet al., 2011), while those with primary checking symptoms have shown worse performance on tests of episodic memory and response inhibition compared to those with primary washing symptoms (Omori et al., 2007). More recently, the symmetry/ordering dimension has been linkedto

poorer verbal fluency, checking/doubting to poorer cognitive flexibility, and contamination to poorer visuospatial construction (Kashyap, Kumar, Kandavel, & Reddy, 2017). These divergent neuropsychological abilities are consistent with OCD symptom presentations showing different neurobiological activation patterns, such as in studies comparing patients with primary checking symptoms to those with primary washing symptoms (e.g., Murayama et al., 2013; Mataix-Cols etal., 2004).

Etiological theories

Although the exact causes of OCD remain unknown, several contemporary theories have outlined a detailed account of the disorder's origin. The most widespread of these theories are 'cognitive-appraisal models' (CAMs), which propose that intrusive thoughts are a normal part ofconscious experience, and only take on an anxiety-provoking or distressing nature in OCD because their meaning is catastrophically misinterpreted. For instance, while an unaffected individual might appraise an intrusive thought about harming their infant as preposterous and unworthy of further consideration, an individual with OCD might interpret this same thought asevidence that they are capable of such an act, thereby provoking significant anxiety and motivation to neutralize its possibility. In support, virtually all people report experiencing an OCD-like intrusive thought on at least an occasional basis (e.g., Belloch, Morillo, Lucero, Cabedo, Carrió, 2004), suggesting that it is the reaction to intrusive thoughts rather than the experience of intrusive thoughts that is cause of obsessions.

The first well-articulated CAM was proposed by Salkovskis (1996), who argued that intrusive thoughts take on an obsessive quality when the person interprets their associated consequence as one for which they would be personally responsible. Salkovkis suggested that this responsibility appraisal arises from more global beliefs about the nature and meaning of thoughts (e.g., thoughts of harm are morally equivalent to harmful actions, failing to prevent harm is the same as causing it, etc.; Salkovskis, 1985), which in turn are acquired through experiences that engender a stricter code of conduct and responsibility (e.g., growing up in an extremely religious household; Salkovskis, Shafran, Rachman, & Freeston, 1999). Theorists later built upon Salkovskis's model by proposing other pathological beliefs that could produce similar distress-evoking misappraisals of intrusive thoughts. The most comprehensive such theory was developed by the Obsessive Compulsive Cognitions Working Group (OCCWG, 2003), who proposed that intrusions could also translate into obsessions via beliefs about the over- importance of thoughts (e.g., belief that a thought has ethical or moral ramifications, or can increase the probability of the corresponding event/behavior), the need to control thoughts (i.e., belief that compete control over one's thoughts is necessary and possible), overestimation of threat (i.e., belief that negative events are especially likely and would be especially awful), perfectionism (i.e., belief that mistakes and imperfection are intolerable), and intolerance of uncertainty (i.e., belief that it is necessary and possible to be certain that negative outcomes will not occur).

Since the development of CAMs, other competing models of OCD pathology have risen to prominence. One such theory was proposed by Szechtman and Woody (2004), who contended that OCD is caused by an abnormality in the so-called "Security Motivation System" (SMS): An evolved threat system designed to detect subtle or hidden indications of danger. Specifically, theauthors propose that OCD persons are unable to generate the "feeling of knowing", which under normal circumstances serves as a satiety signal to shut down the SMS. In this way, the SMS theory breaks from CAMs in considering OCD as a pathology *stopping* (i.e., failure to put a closure on experience) rather than starting (i.e., an anxiety-provoking misappraisal of an intrusive thought that triggers compulsive behavior). The SMS also affords *affective* responses (i.e., subjective feelings of risk) a more central position in the development of OCD compared to*cognitive* responses (i.e., beliefs about the nature of intrusive thoughts), which breaks from the cognitive-focused claims of CAM.

Another contemporary OCD theory is the Inference-Based Approach (IBA) model (O'Connor et al., 2005). The key tenet of the IBA model is that those with OCD are overly reliant on *possibility-based* information (e.g., "my hands *might* be dirty") relative to sensory information (i.e., "I see no dirt on my hands"). This tendency in turn causes remote possibilities to be treated as actual probabilities, which when paired with a distrust of the senses allows such possibilities to take on an obsessional quality. Thus, unlike belief-appraisal models, the IBA model proposes that OCD symptoms are the result

of a distinct *reasoning error* (i.e., overweighting possibility-based information relative to sensory information) rather than one of several beliefs about the nature of intrusive thoughts. Moreover, the IBA model provides several distinct *reasoning devices* that could result in possibility-based information to be overweighed, thereby allowing some mechanistic flexibility in how IBA could lead to the development of different OCD concerns. For instance, OCD patients could come to doubt the veracity of sensory information through errors like over-categorization (e.g., 'this table is dirty because the other table was dirty), over-comparing events (e.g., 'my friend's garage door sprang open so mine could as well'), utilizing out-of-context facts (e.g., 'I could be infected because it's a fact that microbes exist'), or creating imaginary narratives (e.g., 'I saw the red stain and I imagined it wasblood, and that the blood was dripping on me, and so I could be contaminated'; O'Connor, Ecker, Lahoud, & Roberts 2012).

Finally, a more recent model of OCD pathology proposed by Gillan and colleagues suggests that OCD is the result of excessive *habit formation* (Gillan et al., 2014; Gillan & Robbins, 2014; Gillan & Shakarian, 2015). More specifically, this model holds that compulsions,which are manifestations of excessive habit formation, actually develop *prior* to obsessions, which are more or less post-hoc justifications for what the patient perceives as odd and senseless behavior. In this way, the so-called 'habit-hypothesis' breaks significantly from all earlier etiological models by placing compulsions, rather than obsessions, as the primary driver of OCDpathology. Although the habit-

hypothesis has yet to be critically evaluated, its claims are remarkably congruent with neurobiological models of OCD, which emphasize abnormalities in neural areas mediating habit formation (Graybiel, 1997). Moreover, these researchers report that at least some OCD patients use the sort *reverse inference* to justify their habitual actions that the model considers to be the origin of obsessions. For instance, participants retrospectively reported that their avoidance of a particular stimulus must have been because they feared it (Gillan et al., 2014).

OCD Symptom Selectivity

While research has clarified a great deal about the characteristics, treatment, and etiology of OCD, one feature of the illness that has gone largely unexplained is its remarkable selectivity for certain presentations. As early as the 1930s, clinicians noted that certain obsessional themes arose with remarkable frequency, such as those involving sex, contamination, and religion (Lewis, 1936). This sentiment was echoed more recently by prominent OCD epidemiologists Rasmussen and Eisen (1992), who in describing a decade's worth of research cataloguing specific OCD subtypes stated the following about the disorder's selective nature:

> "Inevitably, the beginning clinician is struck by the diversity of the clinical presentations of OCD. This initial impression, however, is soon replaced by the realization that the number and types of obsession and compulsions are remarkably limited and stereotypic. The basic types

> and frequencies of OC symptoms have been found to be consistent acrosscultures and time. Why these particular symptom patterns develop remains unknown" (p. 748).

The notion that OCD shows strong selectivity for certain presentations could have important etiological consequences. Specifically, high selectivity arguably suggests that certainpresentations share (or perhaps trigger) some fundamental characteristic that other, unexpressed (or rarely expressed) presentations do not. As a relevant example, Seligman's highly influential theory of *preparedness* (1971) leveraged the fact that certain phobias were selectively expressedmore than others to identify an important latent similarity shared between them: That common phobias were by and large all "events related to survival of the human species through the long course of evolution" (p. 312). Although significant criticisms and revisions have been made to Seligman's theory (see Öhman & Mineka, 2001 for a review), it nonetheless fostered critical etiological insights into specific phobias, such as the fact that they are mediated by more primitive, subcortical brain areas (Etkin & Wagner, 2007), are observable in young children withno previous phobic contact (Matasaka, Hayakawa, & Kawai, 2010), and are particularly responsive to behavioral treatment (Ost, 1989).

Curiously, none of the modern etiological theories of OCD have attempted to account forthe disorder's selective nature. CAMs contend to certain maladaptive beliefs could give rise to certain obsessive themes;

however, they make no attempt to explain why these rather broad belief structures (e.g., importance of controlling thoughts) would result in very specific kinds of obsessional content. A similar issue exists with the IBA model, which fails to explain why an over-reliance on possibility-based information would result only in a concern with *certain* possibilities. Szechtman and Woody's (2004) theory makes some attempt to explain selectivity by proposing that the Security Motivation System, which fails to properly terminate in OCD, primes humans toward species-specific behaviors aimed at ensuring survival in our evolutionary past, (e.g., checking, cleaning and hoarding). However, it still unclear why such a broad motivation for preservation would manifest in only certain behaviors, as well as why many common OCD behaviors with no evolutionary relevance (e.g., checking if one hit a pedestrian with their car, obsessively testing whether one is gay) would arise in the disorder. Finally, the issue of selectivity is not circumvented by placing compulsions as the driver of OCD, as in Gillan's habit hypothesis. Specifically, if obsessions are merely post-hoc justification for otherwise senseless habitual actions, why do the same justifications arise over and over again in different OCD patients?

There are two possible reasons for why OCD researchers have generally eschewed the topic of symptom selectivity. First, there is no straightforward method of assessing the selectivity of mental illnesses: DSM-based definitions often vary markedly in their phenomenological restrictions, making any judgment of a disorder's selectivity highly subjective. For instance, the fact that

social anxiety disorder typically involves a small number of specific presentations (e.g., concerns with public speaking, eating in public, meeting strangers, and confronting authorities) does not imply that the illness is selective for these presentations since it is definitionally restricted to socially-based fears. Second, OCD is becoming increasingly conceptualized as a markedly heterogeneous condition (e.g., Lochner & Stein, 2003), due in large part to a wealth of evidence demonstrating that its major subtypes are associated with divergent clinical and biological correlates (see previous section). As such, the notion that disparate OCD subtypes share some unifying feature(s), as implied by the disorder's selective nature, has become increasingly de-emphasized and more empirically dubious over time, perhaps reducing enthusiasm for endeavors aimed at characterizing and explaining this phenomenon.

Despite these barriers, I maintain that there is strong evidence for the notion that a) OCD is highly selective for certain obsessional themes, and b) that the OCD subtypes associated with these themes share a common etiological underpinning. In the following two sections, I will review evidence for both these claims.

Evidence for selectivity of obsessional themes

As alluded to above, judgment of a disorder's selectivity for particular presentations involves both a conceptual evaluation of its definitional constraints and an empirical evaluation of its presentational frequencies. More specifically, evidence for selectivity is most compelling if a disorder is broadly

defined but narrowly instantiated, implying that it could involve *many* presentations but in reality only takes on a *few.*

In regard to the conceptual component of selectivity, it is noteworthy that OCD obsessions are defined quite broadly. Specifically, obsession may theoretically involve any thought, urge, or impulse so long as they are recurrent, persistent, and, at some point, experienced as intrusive or unwanted. Further, even though the sufferer must make some attempt to neutralize the thoughts, images, urges, or ideas, there are no constraints on what these neutralization attempts must involve (APA, 2013). Of note, this degree of definitional breadth is fairly unique among affective disorders. As pointed out by Brown, Zinbarg, and Barlow (1993), OCD and generalized anxiety disorder are the only anxiety-related illnesses where an excessively triggered cognitive process (i.e., obsessions and worry) constitutes a core definitional criterion of the disorder. Moreover, the definition of obsessions has changed very little over time (see APA, 1952, p. 33), allowing evidence for selectivity from different decades to be evaluated similarly.

Regarding the empirical component of selectivity, studies have repeatedly demonstrated that OCD gravitates toward a handful of specific obsessional themes. Early on, Dowson (1977) found that fears of contamination, doubts concerning past events, and thoughts of violence, destruction, death, or injury were each present in approximately one-third or more of the study's 41 OCD patients, which was remarkably similar to studies from different continents that used different methodologies (e.g., Akhtar, Wig,

Varma, Perhad, & Verma, 1975). Later, Rasmussen and Eisen (1992) found even more compelling results for obsessional selectivity using a larger (N = 560) sample, where obsessional themes involving contamination, pathological doubting, sex, aggression, somatic concerns, and symmetry were each present in at least a quarter of OCD patients. In another large sample of OCD patients (N = 425), Foa and Kozak (1995) showed that OCD's symptom selectivity is even *higher* when considering only *primary* obsessions (i.e., the three obsessions the patient finds the most distressing or impairing). Specifically, only 1% of thisstudy's sample identified a primary obsession that was not captured by eight distinct categories (Contamination, Fear of harming oneself or others, symmetry, somatic, religious, sexual, hoarding, and unacceptable urges), suggesting that clinically significant obsessional content is exceedingly rare outside of OCD's major categories.

Since these earlier studies, the development and proliferation of the Yale-Brown Obsessive Compulsive Scale Symptom Checklist (Y-BOCS-SC; Goodman et al., 1989) has afforded a wealth of data on the frequency of specific OCD symptom presentations. Recently, I quantitatively reviewed this data by aggregating and comparing the frequency of specific OCD presentations assessed with the Y-BOCS for 9306 OCD patients across 51 studies (Hunt, 2020). Overall, results from this review were remarkably similar to earlier epidemiological studies, demonstrating that at least one fifth of OCD patients reported obsessions involving sexual (20.1%), somatic (28.6%), religious (29.0%), symmetry-related (40.2%), aggressive (58.3%) or

contamination-related (59.5%) themes. Importantly, patients assessed with the Y- BOCS-SC are given definitions for obsessions and compulsions (along with a couple of examples of each) and then asked to enumerate any experiences or behaviors they feel fit those definitions (Goodman et al., 1989). As such, patients typically disclose their symptoms without knowledge that certain presentations are more or less common, thereby increasing confidence that their specific reporting pattern is not just an attempt to fit the instrument's particular categorization structure. Moreover, because the Y-BOCS-SC includes a miscellaneous symptom category, raters should also not be compelled to shoehorn a patient's reported concerns into an ill-fitting category. In support, the proportion of symptom in principal relative to miscellaneous categories is similar across self-report and clinician-administered versions of the Y-BOCS-SC(Marques et al., 2010). Thus, the high prevalence associated with the instrument's principal categories does appear to reflect a rater-related biases for more readily placing symptoms into more commonly recognized categories.

While the principal categories of the Y-BOCS-SC capture fairly specific content, studies reporting frequencies at the item level suggest that OCD is perhaps even more selective for particular presentations than this category-level data suggests. For instance, Pinto et al. (2008) found that 73% of individuals reporting contamination obsessions had concerns with germs or diseases and 40% of those with sexual obsessions had fears of being gay; similar high item-levelfrequencies were reported in a separate study of

pediatric OCD (Storch et al., 2010). There is also a great deal of anecdotal evidence suggesting that OCD has a high affinity for certain highly specific presentations. For instance, contamination OCD is commonly linked with a fear of contracting HIV (e.g., Veale, 2007; Hauser, Eldar, & Dolan, 2016), which has also been assessedas a variable of interest in experimental OCD studies (Riskind & Maddux, 1994), and is commonly mentioned in case studies (e.g., Bruce & Stevens, 1992). Similarly, fears of having accidentally hit someone with one's car are prevalent enough within aggressive OCD to have been garnered the label 'hit-and-run-OCD' (Hyman & Pedrick, 2010), as are fears of murdering one's newborn among recent mothers (i.e., 'post-partum OCD; Zambaldi et al., 2009). The same can be said for sexual OCD, where fears of becoming gay (homosexual OCD, or 'HOCD'; Williams, 2008) or becoming a pedophile (P-OCD; Bruce, Ching, & Williams, 2017) are apparently common enough to warrant their own clinical literatures.

Evidence for etiological uniformity across OCD subtypes

The surfeit of research demonstrating that OCD presentations possess divergent clinical and biological correlates has left little doubt that the illness is not wholly unitary. Thus, if there are conserved etiological processes across OCD's major presentations, they likely exist in addition to, rather than instead of, presentation-specific determinants. Indeed, this is the positionfavored by leading theorists (e.g., Taylor, 2005; Mataix-Cols, 2006), who contend that OCD symptoms are most likely arranged in a hierarchical bifactor model, where specific presentations possess both lower-order factors, reflective of

etiological diversity, and share a single common factor, reflective of etiological uniformity.

Direct support for this hierarchical bifactor model of OCD was recently obtained by Olatunji, Ebesutani, and Abramowitz (2017). Using the recently developed Dimensional Obsessive-Compulsive Scale (DOCS; Abramowitz et al., 2010), these researchers found that a hierarchical bifactor model (general OCD factor + four specific factors) was a far better fit than an unidimensional model (general OCD factor only) or a correlated traits models (four specific factors only) in a heterogeneous sample of OCD patients (n = 246), other psychological disorders(n = 158), and other unselected adults (n = 888). Interestingly, these researchers also found that specific symptom dimensions (contamination, responsibility for harm, unacceptable thoughts, symmetry/ordering) were no longer reliable measures of OCD when levels of the general OCD factor were controlled for. This suggests that the stability of specific OCD symptom dimensions is largely attributable to stability in the general factor underlying all of them.

The findings by Olatunji et al. (2017) are further supported by evidence of biological commonalities across common OCD symptom presentations. For instance, Taylor, King, & Asmundson (2010) found that variance in four of the five symptom subscales of the Obsessive Compulsive Inventory-Revised (Foa et al., 2001)—washing, checking, ordering, obsessing—were more attributable to a shared genetic factor than to unique genetic factors. These same findings were later replicated by Iervolino, Rijsdijk, & Cherkas (2011). Similarly,

Katerberg et al. (2010) found that both a five-factor solution and a one-factor solution emerged as possible solutions to symptom structure data in a large sample of OCD patients, with heritability analyses showing that the single factor was at least as heritable as the most of the of the specific factors. Neurobiologically, there also appears to also be a consensus that OCD dimensions are mediated by distinct, but partially overlapping neural areas (Mataix-Cols et al., 2004; Van Den Huevel et al., 2008), indicating that such presentations share some degree of neurobiological uniformity inaddition to neurobiological divergence.

Etiological uniformity of OCD's major symptom presentations is also implied from the invariance of these presentations across different demographic variables. Specifically, groups of people that are likely to have highly divergent experiences (e.g., children vs. adults; persons from different cultures) generally develop the same types of obsessions, suggesting that these symptoms share some important universal quality. To illustrate such invariance, Table 1 lists the percentage of total obsessions symptoms from each Y-BOCS-SC symptom category for OCD patients of different ages (i.e., children vs. adults; Table 1A) and from different cultural regions (i.e., United States/Europe, South Africa, Middle East, Asia, South America), using data derived from the quantitative review of Y-BOCS-SC studies described earlier (Hunt, 2020). While the symptom proportions of most categories showed statistically significant differences between ages and cultural regions, virtually all differences were below the threshold considered indicative of a small effect (Odds Ratio = 1.68),

and none were close to the threshold considered indicative of a medium-sized effect (Odds Ratio = 3.47; Chen, Cohen, & Chen, 2010). This suggests that while age and culture have some influence on the manifestation of OCD obsessions, such content is more strongly determined by more universal factors that are shared across these demographic subgroups. Interestingly, there is evidence suggesting that the cultural universality of OCD mayapply to intrusive thoughts more generally. Specifically, Radmosky et al. (2014) found the unaffected university from six continents generally endorsed the same specific categories of intrusive thoughts, mirroring results from this clinical data.

Table 1.1. Age-related and cultural differences in the proportion of obsessional themes

Y-BOCS-SC Obsession Category	U.S./Europe Adult N = 2515	U.S./Europe Child N = 2428	
	% Symptoms	% Symptoms	Odds Ratio
Aggressive	28.7	26.4	1.12
Contamination	26.4	26.1	1.02
Symmetry	NA	NA	NA
Magical	NA	NA	NA
Somatic	14.2	13.9	1.04
Religious	11.5	14.5	1.30
Hoarding	10.6	11.4	1.42
Sexual	8.5	7.6	1.13

Y-BOCS-SC Obsession Category	U.S./ Europe N = 2515	South Africa N = 837	Middle East N = 719	Asia N = 2174	South America N = 641	
	% Symptoms	% Symptoms	% Symptoms	% Symptoms	% Symptoms	Odds Ratio (Largest pairwise difference)
Aggressive	23.4	22.3	17.8	24.7	17.2	1.85
Contamination	21.6	19.9	27.4	26.6	20.0	1.52
Symmetry	18.2	17.7	16.4	15.9	17.7	1.18
Somatic	11.6	13.0	10.5	6.2	13.0	2.26
Religious	9.4	10.4	13.4	10.2	12.2	1.19
Hoarding	8.7	10.2	5.2	5.8	11.5	2.07
Sexual	7.0	6.5	9.3	10.6	8.3	1.69

Note. % symptoms refer to the proportion of total obsessions in the total sample that were subsumed by a particular Y-BOCS-SC obsession category. Data is taken from Y-BOCS-SC studies of OCD patients of children and adults from different cultural regions. Y-BOCS-SC =Yale-Brown Obsessive Compulsive Scale Symptom Checklist.

Explanations of Selectivity in OCD

Having reviewed evidence for the notions that a) OCD is highly selective toward particular presentations, and that b) such presentations share a common etiological process, I will now briefly turn to what is, to my knowledge, the only two proposals regarding the origin of such selectivity.

The first proposal, which was reviewed earlier, is that OCD presentations derive from an inflated sense of personal responsibility for harm or damage occurring (Salkovskis, 1985). For instance, compulsive checkers often fear not just they will accidentally allow a burglary, flood, or fire to occur in their home, but that it will be their *fault,* and that others might get hurt because of it. The same is also often true of contamination-related obsessions, which involve fears of accidentally passing along diseases to others as a result of carelessness. Similarly, individuals with OCD often regard the untoward thoughts associated with sexual or aggressive themes as their responsibility, which is central to what makes them aversive to those with the disorder. In support of this theory, inflated responsibility has been repeatedly linked to levels of OCD symptomology in both correlational studies (Rhéaume, Freeston, Dugas, Letarte, & Ladouceur, 1995; Wilson & Chambless, 1999; Salkovskis et al., 2000) and experimental studies (Foa, Amir,Bogert, Molnar, & Przeworski, 2001). Further, Salkovskis et al. (2000) found that heightened

responsibility continued to predict levels of OCD symptoms even after levels of anxiety and depression were controlled for.

Although there is little doubt that inflated responsibility plays an important role in OCD,there a few reasons why this process is an insufficient explanation for selectivity. First, there are many common OCD symptom that do not appear to involve inflated responsibility. Notable examples include some types sexual obsessions (e.g., fear of becoming gay), somatic obsessions (e.g., not being able to stop paying attention to one's blinks/breathing), and symmetry/ordering more generally. Further, it is unclear why an inflated sense of responsibility would result in thosewith OCD only feeling responsible for certain, specific situations, such as harming others or failing to properly secure one's dwelling. Additionally, other empirical studies indicate that the link between OCD symptoms and inflated responsibility is less robust than previously thought.

For instance, there are several studies showing that beliefs about inflated responsibility did not significantly predict OCD symptoms from either the Y-BOCS or the OCI-R when levels of otherobsessive beliefs (i.e., overestimation of threat, perfectionism, importance of controlling thoughts; Obsessive Compulsive Cognition Working Group, 2003) were controlled for (Tolin et al., 2003; Gwilliam, Wells, & Cartwright-Hatton, 2004; Myers & Wells, 2005). Further, Tolin, Worhunsky, ad Maltby (2006) found that while individuals with OCD report elevated levels of perfectionism, intolerance of uncertainty, threat overestimation, and importance of controlling thoughts relative to clinically

anxious controls, they were not elevated on beliefs about inflated responsibility. Thus, although there have been links between OCD and inflated responsibility for harm, other candidate beliefs appear to be more central and specific to OCD pathology.

A more recently proposed commonality across OCD's major subtypes is a heightened fear of death (Menzies, Menzies, & Iverarch, 2015). For instance, compulsive washers are often driven by a desire to prevent chronic or fatal diseases (e.g., HIV) or to reduce exposure to toxins,poisons, or heavy metals capable of causing grave bodily harm; compulsive checkers typically report prevention of fire, home invasion, and death of oneself or loved ones as the reason behindtheir behavior; and persons engaging in atypical compulsions (blinking, tapping, counting to magical numbers) often enact such behavior to prevent harm or death to a loved one (Menzies etal., 2015). As was the case for inflated responsibility, levels of death anxiety, as measured by the Collett-Lester Fear of Death Scale (CLFD; Collett & Lester, 1969), were strongly associated with levels of OCD severity (Menzies & Dar-Nimrod, 2017). Further, this same study showed that priming thoughts of death (but not a different aversive consequence) increased washing behavior (amount of soap used, amount of time spent washing) for clinical OCD participants with primary washing symptoms (Menzies & Dar-Nimrod, 2017).

Though this research suggests that fears of death may contribute to OCD-related fears, this commonality also falls short of explaining presentational selectivity for largely the same reasons as inflated responsibility.

First, many common OCD presentations do not involve a fear of death, including the same ones that were not relevant to inflated responsibility (i.e., fears of becoming gay or becoming a pedophile, fears of never being able to stop paying attention to certain bodily functions) as well as other common manifestations (fearing for the safety of one's *dwelling* in pathological doubting). Along similar lines, while some OCD clients fear physical contamination, which could lead to death, others fear mental contamination (Coughtrey, Shafran,Knibbs, & Rachman, 2012)—which instead involves a concern with taking on the characteristics of an untoward or disliked individual. In addition, fear of death does not appear specific to OCD. For instance, in the study by Menzies & Dar-Nimrod (2017), death anxiety was also strongly correlated with the number of anxiety diagnoses. Indeed, this same group proposed that fear of death may be a transdiagnostic construct underlying many anxiety-related illnesses like somatoform disorders, panic disorder, specific phobia, and separation anxiety disorder. Thus, it is unclear how death-related fears would contribute to the development of commonly observed OCD symptom presentations as opposed to other forms of anxiety-related illnesses.

Conclusions

In summary, the vast majority of OCD cases appear to involve a handful of specific obsessional themes, which may be even more circumscribed than data at the category-level imply. This data is quite suggestive of selectivity because OCD obsessions are defined quite broadly, with little to not phenomenological constraints in regards to particular topics,

concerns,or topics that they must contain. The fact OCD obsessions gravitate toward particular content areas arguably implies these themes share a common etiological underpinning, which is supported by recent factor analytic work favoring the existence of a common underlying dimension, genetic neurobiological data demonstrating the existence of conserved biological markers, and epidemiological research showing the developmental and cultural universality of obsessional content. Only two theories have attempted to account for the selective nature of OCD, and both are arguably insufficient. Thus, despite its etiological significance, OCD symptom selectivity remains a poorly understood phenomenon. In the remainder of this chapter,I will attempt to fill this gap by outlining evidence for a novel, etiologically-relevant commonality across OCD's major obsessional subtypes.

Improbable Catastrophes in OCD

One way to identify commonalities across major obsessional themes is to consider their feared consequences (Foa & Kozak, 1995). Most OCD patients can identify a feared consequence associated with their obsessions (Starcevic et al., 2011) and prevention of such events is often identified as the primary reason for compulsive avoidance (Foa, Abramoitz, Franklin, & Kozak, 1999; Tolin, Abramowitz, Kozak, & Foa, 2001). Perhaps the most straightforward way to categorize these feared consequences, moreover, is on the basis of their probabilities (i.e., how likely the consequence is to occur) and potential severities (i.e., how badthe consequence would be were it to occur). These two variables form the basis for the calculation of expected

value (i.e., value = probability x severity), which is central to models of human choice (Simon, 1955) and to theories of pathological behavior in anxiety disorders (Beck,Emery, & Greenberg, 1985) and OCD specifically (Salkovskis, 1996).

Considering common OCD-relevant consequences on the basis of their costs and probabilities allows an intriguing pattern to emerge: Many, if not most prototypical consequences across the major OCD subtypes involve a specific combination of extremely highcosts and extremely low probabilities. In the following sections, I will illustrate the relevance ofthis characteristic to OCD by reviewing how feared consequences associated with each major presentation (contamination, pathological doubting, scrupulosity, aggressive, sexual, and somatic) exhibit both the high-severity and low-probability components of this commonality.

Contamination

The high severity associated with the consequences of contamination-related OCD were previously summarized by Rachman (2003), who stated that clinically significant contamination concerns usually involve a belief that "the infectious/polluted/dangerous substances will cause serious harm to the person's physical and/or mental health" (p. 1229). The severity of contamination-related consequences is also apparent from items listed on the Y-BOCS-SC, which reference contaminants with the potential of causing great bodily harm (e.g., AIDS: Fishman & Walsh, 1994). In addition, other individuals with contamination OCD report fears of unknowingly spreading

the harmful contaminant to others as a result of not being careful (see Y-BOCS-SC, contamination item 7)— a consequence likely associated with severe and debilitating guilt. Somewhat less severe but nonetheless catastrophic consequences are arguably present in so-called 'mental contamination'. For instance, Coughtrey, Shafran, Lee, and Rachman, (2013) describe a patient with contamination OCD who was afraid that having 'bad thoughts' would result in her morphing into people she felt were undesirable (alcoholics, obese individuals),which would in turn lead to abandonment by her loved ones.

Consequences commonly associated with contamination are also extremely unlikely in their particular contexts. Deadly infectious diseases are rarely contracted in modern society, and unknowingly passing these diseases on to others is even rarer. Additionally, patients often believe that these infectious diseases will transfer through mediums that medical science has deemed impossible, such as catching HIV from a doorknob. On top of this, it bears reminding that individuals with contamination fears continue to worry about contact with these contaminants despite extensive washing and cleaning rituals that make the chance of them occurring even more unlikely. Finally, mental contamination clearly defies causal laws of the physical universe by assuming that untoward characteristics can be contracted between people in the same way that diseases are spread.

Notably, a small but significant subset of persons with contamination OCD report a desire to wash or clean solely to avoid/prevent the *feeling* of

contamination. Although this feeling is no doubt distressing, it does not arise to the level of severity of other contamination- related consequences. Moreover, the probability of this consequence occurring is almost certain: OCD individuals invariably experience a feeling of contamination when in contact with a potential contaminant. Accordingly, this consequence does not fit the mold of improbable catastrophes as well as other contamination-related outcomes, as it appears to represent a less severe and more probable consequence. However, some authors have described cases of contamination OCD in which this feared consequence involves *never* feeling clean again (Abramowitz, 2006). The outcome in these cases is clearly both very severe and very unlikely, especially considering that the person has experienced countless instances where the unclean feeling eventually subsided.

Pathological doubting

Generally, pathological doubting involves concerns that something disastrous will happen because the individual has failed to check something thoroughly or completely, even while realizing that the possibility is extremely remote (Rasmussen & Eisen, 1992). Thus, perhaps more than any other symptom presentation, pathological doubting is conceptualized in a way that directly incorporates the notion of improbable catastrophes. The relevance of SIC to pathological doubting is further underscored when considering the subtype's specific presentations, which typically involve fears of having not turned off/secured measures related to household safety or security, such as water taps, locks, windows, stove tops, and others (Goodman et al., 1989; Foa

et al., 2002). Moreover, the consequences associated with having failed to turn off/secure these measures—burglary, fire, and flooding—are obviously quite severe, and may also be considered improbable on the basis that a) the person has likely already checked that these things were secured, b) sufferer is unlikely to be the kind of person that leaves these measures unsecured, and c) the events themselves have quite low base rates even in cases when these security measures were not taken.

The low-probability and high-severity features of improbable catastrophes also apply readily to less prototypical forms of pathological doubting. For instance, consider 'hit-and-run'OCD: the fear that one has accidentally run over a pedestrian with their vehicle. The cost of accidentally hitting and (perhaps) killing a pedestrian is obviously quite severe, but the event also has a very low base rate. Moreover, fear of this outcome often persists among pathological doubters even after they have repeatedly checked the spot where the accident supposedly occurred or thoroughly surveyed the nightly news for reported incidents of hit-and-runs (Hyman& Pedrick, 2009). Other, more idiosyncratic examples of pathological doubting also demonstrate this pattern. For instance, Hyman and Pedrick (2009) describe a case of a woman who constantlyreturned to check whether her car was locked and the parking brake was off in order to ensure that a child would not climb in and get hurt. Again, while the cost of this outcome is objectively quite severe, it also requires a chain of causal events whose combined probability is clearly very low (i.e., car is actually unlocked, an unsupervised child would

need to pass her car, the child would need to climb in, and the child would need to get hurt once inside the car).

Scrupulosity

The feared consequences associated with scrupulosity (religious OCD) are typically thosethat would occur as a result of being a sinful or immoral person. As one might expect, these particular consequences shift based on one's particular religious doctrine. For instance, scrupulous Christians are often concerned about offending God, going to hell, and devil worship while scrupulous Jews are often concerned with behavioral requirements or laws surrounding ritual purity, Sabbath observance, or dietary laws (Siev, Baer, & Minichiello, 2011).

Contrastingly, scrupulous Muslims may be concerned with having stated prayers correctly whileHindus may be overly concerned with cleanliness or purity (Abramowitz & Jacoby, 2014). Although scrupulous obsessions may vary markedly across religious doctrines, most forms of scrupulosity appear to be undergirded by a fear of divine punishment or retribution, consistent with viewing their particular deity as overly punitive (Grayson, 2014). Indeed, Siev et al. (2011) found that levels of scrupulosity were positively correlated with a negative (punitive) concept of God, but uncorrelated with a positive concept of God. Further, fears related to retribution by godemerged as one of two unique factors on a self-report inventory assessing the frequency of common scrupulosity complaints known as the Penn Inventory of Scrupulosity (PIOS; Abramowitz, Huppert, Cohen, Tolin, & Cahill, 2002). Notably, this instrument

was developed ina sample who identified as Jewish, Cathoilic, Protestant—reinforcing the notion that this fear of god underlies scrupulosity independent of the patient's particular religious doctrine.

Since the god of Christianity, Judaism, and Islam is usually regarded as omnipotent, the consequences this deity could exact may obviously be quite severe. The most common and obvious example of this sort of divine retribution is being sent to hell—which is described in Christianity as a consequence more severe than any other. Others however, may fear divine retribution by god in the current world, such as the invocation of severe punishment on themselves or a loved one (Abramowitz & Jacoby, 2014).

The likelihoods of scrupulosity's consequences are somewhat more difficult to define given that, in many cases, they are unknowable. For instance, the probability going to hell cannotbe evaluated since it is conceived as occurring after death. Still, the committed sins associated with scrupulosity are virtually always pardonable, not central to the religion, or not even considered wrong (Siev et al., 2011; Abramowitz & Jacoby, 2014). Moreover, scrupulous fears often persist despite reassurance from religious officials that the acts in question are indeed benign and not offensive to god. For instance, Abramowitz (2006) describes the case of a Jewish man with OCD who repeatedly called his rabbi to ensure that he had not violated the fasting laws of Yom Kippur by accidentally swallowing his saliva. Thus, even when considered in a purely religious context, the supposed sins of scrupulosity have a very low likelihood of truly being sins. Combined with the low probability of such sins (if actually

wrong) evoking divine punishment, it is clear that the consequences commonly seen in scrupulosity are indeed very improbable.

Aggressive OCD

In contrast to pathological doubting, where the individual is afraid of *accidentally* causing harm or damage, the common thread across aggressive obsessions is that the individual is afraid of committing *purposeful* aggressive or untoward acts toward themselves or others (Moulding, Aardema, & O'Connor, 2014). Perhaps the most common fear in this category is of snapping and harming one's loved ones. For instance, fears of harming newborns are particularlycommon among recent mothers with OCD (Zambaldi et al., 2014), though these obsessions may also relate to other family members (Aardema & O'Connor, 2007). Aggressive obsessions about perpetrating sexual or physical violence against strangers are also commonly reported, particularly those aimed at vulnerable members of society like older adults and children (Abramowitz, 2006; Moudling et al., 2014). In addition, aggressive obsession also often involve fears of suddenly doing serious harm to oneself; for instance, 18.2% of patients in one sample reported aggressive obsessions about potentially harming themselves—about half the prevalenceof obsessions about harming others (Pinto et al., 2008). Such estimates do not clarify the specific means of self-harm, but anecdotal evidence suggests it is often a fear of committing suicide. For instance, Abramowitz (2006) cites a case of an individual troubled by obsessions that he/she will suddenly jump in front of an oncoming train.

The severity of the consequences across these examples is apparent: To kill oneself or one's loved ones are among some of the worst consequences imaginable. Further, even if the acts are committed against a stranger, the legal and social consequences associated with such acts would be severe, not to mention the overwhelming guilt they would likely bring. For some though, much of the distress associated with aggressive obsessions arises from interpreting their thoughts as evidence that they are a monstrous or terrible person. Indeed, these beliefs are often serious and severe enough for the individual to request being locked away both as a precautionand a punishment (Rasmussen & Eisen, 1992).

The improbable nature of aggressive obsessions is apparent from the fact that those who develop them almost always lack a violent history (Rasmussen & Eisen, 1992). Indeed, researchers believe aggressive obsessions arise in individuals for whom they are the most ego- dystonic—that is, most objectionable to one's sense of self (Lee & Known, 2003). This anecdotal observation is also supported in a study by Aardema (2013), who found that levels of ego-dystonicity uniquely predicted repugnant obsessions (i.e., aggressive and sexual ones) but not levels of other symptom presentations. The same can also be said for individuals who simplyfear they are an evil or monstrous person: The probability that someone is such a person becausethey had a fleeting thought of violence is extremely low, especially given that the thought does not elicit pleasure but rather guilt, distress, or anxiety.

Of note, there are less common examples of aggressive obsessions that

are somewhat less severe. Suddenly yelling aggressive obscenities or insults is cited as a particularly common consequence (see Y-BOCS-SC aggressive obsessions item #4), particularly in situations where such statements would be shameful, such as church (Hyman & Pedrick, 2009). The consequences (embarrassment, social approbation) associated with these actions are obviously less severe than murder, suicide, or being a monster. Like other aggressive obsessions, however, these actions are very ego-dystonic to the individual—underscoring the fact that despite their less severe nature they may still be considered extremely improbable.

Sexual OCD

Within the category of sexual obsessions, at least half of individuals report fears of becoming homosexual and about a third report fears of being attracted to a family member (Pinto et al., 2008). Another commonly cited example involves a fear that one is sexually attracted to children (i.e., POCD; e.g., O'Neil, Cather, Fishel, & Kafka, 2005; Bruce et al., 2018).

The improbable nature of the consequences associated with sexual obsessions may be understood in a similar fashion as aggressive obsessions: The obsessions are experienced as extremely ego-dystonic and repugnant to the individual (Williams, 2008; Moulding et al., 2014;Bruce et al., 2018), rendering the likelihood that one actually possesses this feared attraction quite remote (Gordon, 2002). Consequently, the probability that one both possesses this secret attraction *and* will act on is even lower. Moreover, sexual obsessions usually persist after the individual performs extensive tests proving

they do not possess this secret attraction. For instance, individuals with homosexual OCD may repeatedly watch homosexual pornography tocheck that they are not aroused by members of the same sex, but will continue to doubt their sexuality even after these activities fail to induce arousal (Williams, 2008).

The high severity of some consequences associated with sexual OCD are obvious. For instance, pedophiles are regarded as monsters in modern society, so the possibility that one possesses this attraction is clearly catastrophic. The possibility of acting on these desires is even worse, as it would result in severe social approbation and legal consequences. In contrast, fears of being secretly homosexual appear comparatively less severe: Homosexuality is not illegal andis becoming gradually more accepted and supported by society in the modern era (Glick, Cleary, & Golden, 2015). Still, because sexual obsessions are perceived as extremely ego-dystonic, those who develop HOCD may be particularly repulsed by the idea of *themselves* becoming homosexual, even if they do not have moral issues with homosexuality in general. Additionally, while gradually becoming homosexuality may be comparatively less severe, *suddenly* becoming homosexual could be extremely costly. Specifically, this sudden shift in one's sexual identity would be a huge life-altering disruption for those with families or in long-term committed relationships, as their changed orientation could lead to the loss of their partner or possibly the loss of their children. Along similar lines, individuals from more conservative families may associate

homosexuality with familial rejection—another quite severe cost. Importantly, all these potential consequences readily apply to incestuous sexual obsessions as well. Thus, while research on OCD presentations is not granular enough to verify the high severity of many sexual-based obsessions, there is still clear reason to suspect that for some individuals, sexual obsessions involve subjectively severe consequences.

Somatic OCD

Somatic OCD involves an obsessive preoccupation with one's body or bodily functions. Most commonly, somatic OCD crystallizes around the fear of having some terrible disorder, disease, or condition (Rasmussen & Eisen, 1992; Fallon, Qureshi, Laje, & Klein, 2000). For instance, Fallon et al. (2000) described cases of OCD patients with fears of having contracted mad cow disease and cases of OCD patients with more generalized somatic fears about commondeadly afflictions like heart disease or cancer. However, somatic OCD may also involve other types of body-related obsessions, such as fears of being the unable to stop paying attention to normal bodily processes like blinking, breathing, or swallowing. In these cases, the person may become worried that they are performing this process oddly or incorrectly, may *never* be able to stop focusing on it, and may go insane as a result (e.g., Hyman & Pedrick, 2009). Finally, somatic OCD may also include obsessions related to abnormalities in one's physical appearance,for instance, obsessively wondering if one breast is larger than the other (Abramowitz, 2006). Indeed, in the sample reported by Pinto et al. (2008) obsessive concern with a body part or appearance was about

half as common (15.5%) as concerns with illness or disease (28.7%).

Regarding severity, the diseases typically feared by those with somatic OCD are typicallyserious or life-threatening (cancer, heart disease, dementia). Similarly, the prospect of losing one's sanity as the result of *never* being able to ignore a bodily process is also an objectively catastrophic outcome. Obsessive concerns with appearance, on the other hand, appear to involve less severe consequences. While this outcome may involve feelings of inadequacy, social rejection, and difficulty finding a romantic partner, they arguably do not rise to the severity level of other consequences in somatic OCD. Like homosexual concerns however, it could be the casethat concerns with appearance are still *subjectively* catastrophic to the individual. Although research on somatic OCD is too sparse to verify these claims, research on a disorder with closely intertwined phenomenology to appearance-related OCD—body dysmorphic disorder (BDD)— offers some important guidance. For instance, in Phillips' (2005) book "The Broken Mirror", she describes cases of BDD patients for whom slight or even non-existent abnormalities led to them to perceive themselves as monsters who should not even be seen in public, and who considered themselves as "one of the ugliest people in the whole world" (p. 7). Indeed, Phillips (2005) reports that one patient actually stated that she would "be happy to have cancer, because it wouldn't isolate me the way this [her BDD obsessions about appearance] does" (p. 4). Accordingly, those with appearance-related somatic obsessions may indeed perceive the consequences of such abnormalities as very severe, even if they are not as objectively terrible

as other consequences commonly associated with this presentation.

Regarding the probability of these consequences, it is clear that they are all quite remote. The diseases feared by those with somatic OCD are typically very rare for their age or history (e.g., cancer in a young person) and they continue to be concerned with these maladies despite repeated assurance from medical professionals. Never being able to remove focus from a bodily process, and thereby going insane, arguably has an even lower probability. Although this consequence is imaginable, instances of this actually occurring are exceedingly rare, if they occur at all. Finally, the notion the one is indeed the ugliest or most monstrous person in the world is clearly very improbable, especially considering that the one's friends, family members,and clinicians constantly offer constant reassurance of intact appearance (Phillips, 2005).

Symmetry and exactness

The consequences associated with symmetry/exactness obsessions are typically divided into two distinct categories: Those accompanied with magical thinking and those that are not (Rasmussen & Eisen, 1992; Goodman et al., 1989). Symmetry/exactness obsessions accompanied by magical thinking may involve fastidious attempts to line up, straighten, or count objects in a certain way in an attempt to prevent the occurrence of some disastrous event that would otherwise be uncontrollable (e.g., death of a family member). Thus, these consequences obviously fit the mold of an improbable catastrophe: The feared event is clearly disastrous and the 'magical' connection between the person's action and prevention of this severe consequence renders it highly

improbable.

In contrast, the link between improbable catastrophes and symmetry/exactness-related consequences *without* magical thinking is more tenuous. Specifically, individuals with these obsessions are driven to straighten/reorder objects primarily in response to a nagging feeling of 'incompleteness' or 'just-not-right experience' (NJRE) that occurs when objects are in a state ofdisorganization or misalignment (Coles, Frost, Heimberg, Rhéaume, 2003; Summerfeldt, 2004).The empirical link between symmetry/exactness and incompleteness/NJREs is also very robust: Symmetry/ordering has been found to be exclusively predicted by levels of incompleteness in both clinical samples (Ecker & Gönner, 2008) and nonclinical samples (Pietrefesa & Coles, 2008; Summerfeldt, Gilbert, & Reynolds, 2015). Such feelings are arguably much more probable(i.e., they will absolutely certainly occur/continue to occur if the objects are straightened/reordered) and much less severe (i.e., not actual catastrophic event is feared) than other common OCD concerns, and thus do not cohere very well to the features of improbable catastrophes. Moreover, symmetry obsessions *without* magical thinking have been shown to be more prevalent (31.8%) than those *with* magical thinking (20.8%) in the sample reported by Pinto et al. (2008), meaning the number of OCD patients exhibiting these symmetry/exactness obsessions is far from trivial.

Hoarding

Although hoarding is now considered a separate disorder from OCD, I

will still consider it here given that it is recognized as an OCD symptom on some clinical assessment tools (Y- BOCS-SC, OCI-R). Individuals with hoarding disorder (HD) are characterized by both a) excessive acquisition of items and b) difficulty throwing away possessions, resulting in severely cluttered personal spaces (Frost & Hartl, 1996). Typically, the items individuals with HD collect and save have little to no use or value (Maier, 2004). Moreover, the major reason hoarders reportwanting to save these items is the belief that they may serve a purpose in the future. For instance,in an early study of 108 hoarders by Frost and Gross (1993), the most common reason for saving items was that they could potentially be used at some later date (mean prevalence rating of 4.8 ona 5-point scale).

The maladaptive nature of HD comes from the fact that the items are indeed useless andcontinue to be useless, even after being saved for years. Thus, the notion that a discarded (useless) item could serve some important use in the future is clearly a very low probability event. Of course, the severity of this consequence is also very low: If the person's fear was proved correct (i.e., they encountered a situation in which the discarded item *would* have been useful) the situation could be easily rectified since the item is, by definition, common and easilyobtainable. Accordingly, hoarding is linked with OCD in being characterized by improbable fears but appears to break from the illness by involving more benign consequences.

Summary of Improbable catastrophes across OCD presentations

A summary of the probabilities and costs associated with feared

consequences across the major OCD subtypes are shown below in Table 1.2. Overall, it appears that most feared consequences associated with OCD may be considered both improbable and catastrophic. Given that these consequences could theoretically involve any cost x probability combination, the preponderance of OCD-relevant consequences fitting this pattern suggests the disorder involves a more general *sensitivity to improbable catastrophes* or SIC.

Importantly, this commonality appears across presentations associated with different symptom dimensions (e.g., contamination,taboo thoughts; Bloch et al., 2008), suggesting that it may constitute a more general etiological process that exists alongside dimension-specific determinants (Olatunji et al., 2017; Taylor, 2005).

The major exceptions to the improbable catastrophe rule were outcomes where the feared consequence was a subjectively distressful feeling rather than a specific external event. This included the feeling of dirtiness or pollution in contamination OCD and the feeling of incompleteness or just-not-rightness in symmetry/exactness OCD. However, the feeling-related consequences of contamination OCD may still cohere to the pattern of SIC if the individual fearsthe improbable, catastrophic consequence of *never* feeling clean again. Thus, obsessions with symmetry/exactness stand as perhaps the one major exception to the improbable catastrophe ruleamong the common OCD presentations.

Notably, the improbable dimension of SIC appeared to be a more consistent feature of OCD-relevant consequences compared to the

Table 1.2. Probability and cost estimates of feared consequences across major OCD subtypes.

	Feared Consequences in OCD		
OCD Subtype	**Prototypical example**	**Likelihood**	**Cost**
Contamination /Washing	Contracting a deadly infectious disease (e.g., HIV) from a public surface	Very low	Very high
	Getting poisoned from contact with a household cleaner	Very low	Very high
	Taking on the characteristics of an immoral person after meeting them	Very low	High
Doubting /Checking	Failing to prevent a fire, flood, or burglary after not checking stovetops, water taps, and locks	Low	High
	Accidentally hitting and killing a pedestrian without knowing it	Very low	Very high
	Failing to prevent a family member from dying after not saying a certain word/phrase	Very low	Very high
Aggressive OCD	Suddenly drowning, stabbing, or shooting one's child	Very low	Very high
	Suddenly deciding to jump off a bridge, drink bleach, or shoot oneself	Very low	Very high
	Secretly and intentionally poisoning someone	Very low	Very High
Religious OCD	Being sent to hell for an immoral thought or trivial act (e.g., accidentally taking a pen)	Very low	Very High
	Suddenly shouting obscenities in church	Very low	Moderate
	Incurring divine punishment (e.g. death of family member) for not praying correctly	Very low	Very High
Sexual OCD	Acting on secret pedophilic desires	Very low	Very high
	Acting on secret incestuous desires	Very low	High
	Acting on secret homosexual desires	Very low	High
Somatic OCD	Failing to catch symptoms of a deadly disease (e.g., skin cancer) in time to prevent it	Low	Very High
	Choking after not chewing food well enough	Very low	Very High
	Going insane from continuously monitoring a bodily function (e.g., blinking, breathing)	Low	High
Symmetry /Ordering	Being seen as disorderly or unorganized by others despite being the opposite	Moderate	Low
	Failing to live up to one's high standards	High	Low
	Making a mistake at work/at school	Low	Low

catastrophic one. For instance, even though consequences like becoming gay, being ugly, and yelling obscenities involved less objectively severe outcomes, they would still be considered highly improbable. This suggests that a heightened concern for low probabilities events may be a more abiding feature of OCD pathology compared to a concern with catastrophic outcomes.

Improbable Catastrophes in Other Anxiety-related Conditions

While demonstrating the universality of SIC across the major OCD subtypes is a crucial step for establishing its relevance to the disorder, so too is demonstrating that this characteristic exhibits *specificity* for OCD. In other words, if SIC truly contributes to the development or maintenance of OCD, but not other forms of anxiety pathology, the fears prominently associated with other anxiety-related conditions should not involve improbable catastrophe nearly as often as those commonly associated with OCD. In this section, I will review the relevance of improbable, catastrophic concerns in other anxiety-related conditions in an effort to evaluate the specificity of SIC to OCD.

Panic disorder

Unlike fears in OCD, feared consequence associated with panic disorder is listed directly in the diagnostic criteria: Worry about having a panic attack, which persists for at least a month (American Psychiatric Association, 2013). Regarding severity, panic attacks are known to be extremely aversive, with anxiety so severe in some cases that the sufferer reportedly feels as if they are dying (McNally, 1994). At the same time, panic attacks are brief, peaking within 10-15 minutes by definition (American Psychiatric Association, 2013).

Thus, while the experience of apanic attack is severe, its temporary nature arguably renders it less objectively severe compared to many of the common concerns associated with OCD, which often involve permanent and harmful damage (e.g., chronic disease, loss of family member, loss of home, death). More importantly though, panic attacks are quite probable for those with panic disorder. For instance,Reed & Wittchen (1998) found that 41% of individuals with panic disorder experienced 5 or more panic attacks per month. Thus, panic attacks are clearly not improbable catastrophes in thesame way as the concerns typically associated with OCD.

Social Anxiety Disorder

Individuals with social anxiety disorder (SAD) exhibit a heightened concern with social encounters or performance situations in which the individual will be subjected to scrutiny and may act in a way that is humiliating or embarrassing (American Psychiatric Association, 2013). Common social fears for SAD include public speaking (most common), writing in front of others, eating in front of others, and a generalized type that pertains to many social situations (Ramshaw, Chavira, & Stein, 2010).

Some consequences associated with SAD may be improbable and at least moderately severe. For instance, some SAD patients fear that failure in social situations will result in a loss of status and worth and social rejection (Clark & Wells, 1995), which is both fairly severe and quite unlikely to arise from a social misstep. Of course, the severity of these consequences still do not arise to the level of many associated with OCD (e.g., hell, death, murder of

children, AIDS, etc.). Moreover, most individuals with SAD are merely concerned with being criticized orwith doing something embarrassing, which are clearly less severe and more probable relative to most OCD-relevant fears. For instance, mistakes occur quite frequently during public presentations and do not typically involve any direct consequences. Thus, socially-relevant fears in SAD do not typically involve improbable catastrophes, illustrating that the disorder is likelynot characterized by an underlying sensitivity to such circumstances.

Generalized Anxiety Disorder

The cardinal feature of generalized anxiety disorder (GAD) is persistent and uncontrollable worry (American Psychiatric Association, 2013), which may involve a broad- range of categories like work-related conflicts, family issues, finances, social concerns, physicalhealth, family member health, or even the general state of the world (Becker, Goodwin, Hölting,Hoyer, & Margraf, 2003).

Data on specific feared consequences within these categories is sparse, but studies comparing worries of GAD individuals to unaffected individuals are quite illuminating. For one, Craske, Rapee, Jackel, and Barlow (1989) found few differences between GAD individuals and unaffected individuals on most content worry areas. Moreover, the probability of the worry occurring was the same across these groups, indicating GAD individuals do not fear consequences that are less probable than unaffected individuals. However, Craske et al. (1989) did find that a miscellaneous worry category was more

frequently endorsed by GAD patients.

Because this category included a mix of probable, benign worries (e.g., accidentally dropping aplate) and improbable, catastrophic worries (e.g., nuclear war), it was difficult to determine which types of worries were driving this increase in prevalence.

Fortunately, Roemer, Molina, and Borkovec (1997) conduced a follow-up study in which they compared the reported frequency of worries within this miscellaneous category between GAD individuals and healthy controls. In this study, GAD individuals reported a much higher prevalence of worries within a category called *daily hassles*, which included concerns of minor or routine issues (e.g., forgetting to pay a bill). Thus, a distinguishing feature of GAD appears to be, if anything, a propensity to worry about consequences that are both *less severe* and *more probable*—the exact opposite pattern of OCD. This is also consistent with the clinical languagein the DSM used to differentiate GAD and OCD, which states that OCD obsessions cannot simply be worries about everyday activities in contrast to those in GAD.

Specific Phobia

Similar to the feared consequences in OCD, the outcomes associated with Specific phobia (SP) tend to gravitate toward a handful of specific content areas. Indeed, SP is distinguished by five specific subtypes that reflect the most common types of fears: Animal type (e.g. snakes, spiders), natural environment type (e.g., heights, storms, deep water), situational type (e.g., enclosed places, flying on airplanes), blood-injury-injection type (needles,

blood), andan ‘other’ category type (e.g., suffocation; Wolpe & Lang, 1974).

In terms of probability and severity, there is clear heterogeneity across the common fears in SP. Bites or encounters with snakes or spiders, while not common, are still much more probable than prototypical OCD fears, and are also quite less severe. Similarly, the major fears associated with blood-injury-injection phobia are fainting (Page, 1994) and pain (e.g., De Jongh et al., 1998), both of which are also less severe and more probable than what would be considered improbable catastrophes. In contrast, fears subsumed by the natural environment type(e.g., fear of falling from a high height, being struck by lightning, drowning in deep water), the situational type (e.g., being in a plane crash) and the ‘other type’ (e.g., being suffocated) are often on par with OCD-relevant fears in terms of both their low probabilities and high severities. Interestingly, subtypes with more relevance to improbable catastrophes are also more likely to driven a desire to prevent harm: 84% of those with natural environment phobias report catastrophes/harm as their feared consequence, whereas the number is 54% for situational, 25% for animal, and 10% for blood-injection-injury (Lipsitz, Barlow, Mannuzza, Hoffman, & Fyer, 2002).

Although some fears in SP fit improbable catastrophes fairly well, the pattern is arguably still less consistent than it is in OCD. Specifically, while improbable catastrophes are observed across virtually all the major subtypes of OCD, the outcome is only relevant for around half the major categories of SP. Moreover, SP has a common thread that accounts for its constellation offears more readily than improbable catastrophes: They all relate to threats relevant

to survival inour evolutionary past (Seligman, 1971). These evolutionary threats will obviously be quite severe because they were selected to respond to life-threatening dangers, and they may also be less probable because the environments that drove their selection is markedly different from the one we live in today. For instance, excessive fears of snakes are less adaptive today because encounters with snakes are less common and because known antidotes to their venoms exist. Thus, the fact that SP-related fears sometimes involve improbable catastrophes may be anartefact of them being evolutionarily-salient fears, rather than reflecting a sensitivity to improbable catastrophes per se.

Nonetheless, it cannot be ruled out that a sensitivity to improbable catastrophes is an areaof partial etiological overlap between SP and OCD. In support, in a large Korean sample (N = 6152), the co-occurrence between OCD and specific SP subtypes was by far the greatest (and theonly to be significant) for natural environment subtype (Park et al., 2013)—which is also the subtype whose content is most consistent with improbable catastrophes..

Separation Anxiety Disorder

Perhaps more than any other anxiety-related illness, separation anxiety disorder involvesa feared consequence that arises to the level of an improbable catastrophe. Specifically, separation anxiety disorder is defined by fears of being separated from one's household or primary caregiver, including concerns that harm will befall one's caregivers or self during theseparation (APA, 2013). Losing a parent is one of the most severe things that can happen to achild, and is also (fortunately) highly improbable. Thus, the central fear in

separation anxiety disorder is phenomenologically consistent with consequences common to OCD.

Although permanent caregiver separation is both improbable and catastrophic, one aspect that differentiates this fear from OCD-relevant concerns is its normative and adaptive nature. Specifically, most children go through some period of excessive attachment to their caregiver,which is both evolutionarily advantageous and helpful for developing a sense of safety and security (Weinfeld, Sroufe, Egeland, & Carlson, 2008). Thus, separation anxiety may be more accurately conceived as a failure to resolve a developmentally-appropriate fear rather than a sensitivity to improbable catastrophes. This point is further demonstrated by the fact that most cases of separation anxiety disorder are circumscribed to caregiver-separation and not generalized to other, improbable catastrophic outcomes (Costello, Egger, & Angold, 2005).

Despite the differences, it cannot be ruled out that SIC might manifest as caregiver separation fears early in life and other, OCD-relevant concerns later on. In support, anywhere from 20% to 33% of OCD patients report a history of separation anxiety (Ruscio et al., 2010; Lewinsohn, Zinbarg, Seeley, Lewinsohn, & Sack, 1997) and there is evidence that rates are even higher rates in early-onset cases of OCD (Mroczkowski et al. 2011). Clinicians have also noted that harm-related obsessions in OCD and are difficult to distinguish from separation anxiety in children (Mroczkowski et al. 2011), again underscoring the face-valid relevance of separation anxiety to OCD-relevant

improbable catastrophes. However, the notion that separation anxiety represents an early indicator of SIC is merely speculative as there is no direct evidence capable of supporting the assertion at the current time.

Post-Traumatic Stress Disorder

Post-traumatic stress disorder (PTSD) centers around the distress, avoidance, and re-experiencing of past harmful events (APA, 2013). The traumatic events that produce these debilitating reactions are usually quite severe, including rape, serious car accidents, robbery, or dangerous military conflicts. Thus, anxious apprehension about these events re-occurring clearly matches the high-cost dimension of an improbable catastrophe.

However, the fact the individual actually experienced these severe events indicates that they are clearly more probable than those associated with OCD. Specifically, while consequences feared in OCD are often borderline impossible (e.g., getting HIV from a doorknob,snapping and killing a family member in the absence of violent history/intentions) or unknowable (being sent to hell for a trivial immoral thought) the precipitating events in PTSD are, unfortunately, relatively common. For instance, in a sample of N = 2953 U.S. adults, Kilpatrick et al. (2013) found that 90% of the population had experienced a PTSD trauma at some point in their lives, and that participants on average had experienced three traumatic events. Moreover, many individuals with PTSD are not necessarily afraid of the traumatic event re-occurring, but rather the memories or feelings associated with the event (APA, 2013). Accordingly, anxious apprehension about improbable catastrophes does

not appear to be adefinable feature of PTSD, which typically involve concerns with more probable events orevents that occurred in the past.

Summary of improbable catastrophes in other anxiety-related conditions.

The phenomenology of most anxiety-related conditions indicates that a heightenedconcern with improbable catastrophes is not a generalized feature of anxiety pathology. Specifically, most anxiety-related conditions involve fears that are neither improbable nor catastrophic (panic attacks in panic disorder, criticism/social mistakes in SAD, worries about daily hassles in GAD), while those with concerns better approximating improbable catastrophes are more parsimoniously explained by other shared features (e.g., evolutionary-salient threats in SP) or are completely confined to one category of threat (e.g., fear of being separated from caregivers in separation anxiety disorder). Thus, OCD-relevant consequences appear to fit the improbable catastrophe pattern far better than other anxiety-related conditions, suggesting the sensitivity to these events is a fairly specific feature of the disorder. Nonetheless, there is some evidence that disorders involving fears with more relatedness to improbable catastrophes are often comorbid with OCD (e.g., fear of environmental threats like drowning in SP), suggesting SIC may partially cuts across other categories of anxiety-related disorders.

Explanations for the Sensitivity to Improbable Catastrophes in OCD

Given that SIC appears to be a fairly sensitive and specific feature of OCD, the nextlogical question is why this link exists. In other words, why are

those with OCD sensitive to improbable catastrophes as opposed to other types of outcomes?

A useful starting point for answering this question is with the tendency to overestimate threat (OET), which is widely viewed as a core cognitive bias in OCD (OCCWG, 2003) that is commonly elevated among those with the disorder (e.g., Meyers, Fisher, & Wells 2008). Accordingly, those with OCD could be sensitive to improbable catastrophes as a result of overestimating their probabilities, their costs, or both. Nonetheless, while OET is clearly relevant to OCD, there are two reasons why this construct is insufficient for explaining the purported links between SIC and OCD on its own.

First, OET is not specific to OCD: Clinicians have long observed OET to be a general feature of anxiety-related condition rather than a specific feature of OCD (Beck, 1976). Similarly, when controlling for levels of trait anxiety, OET (as measured by the Obsessive Beliefs Questionnaire [OBQ]; Myers et al., 2008) is elevated equally across OCD participants and those with other anxiety disorders (Tolin et al., 2006), suggesting it cannot explain why a sensitivity to improbable catastrophes arises in OCD *specifically.* Second, because OET pertainsto a generally disposition to overestimate the probability and severity of threat (OCCWG, 2003),it cannot explain why OCD individuals tend to only overestimate the risk/harm associated with improbable catastrophes. If OET were the driving force behind OCD symptoms, the disorder should have feared consequences involving a wide range of probability and cost combinations,

which the phenomenological evidence reviewed earlier suggests is clearly not the case.

Given the issues with using OET to explain SIC, it appears that whatever threat-based distortion is contributing to this process needs to be both focally tailored to improbable catastrophes and relatively specific to OCD. In other words, the most likely candidates for explaining SIC will be OCD-specific traits/processes that could result in those with OCD overestimating either a) the likelihood of improbable threats, or b) the cost of catastrophic ones. In the proceeding sections, I will review how several OCD-relevant psychological processes within each threat-distortion category satisfy these criteria.

Overestimation of Improbable Threat Likelihood in OCD

OCD has been linked to elevations in a number of psychological constructs that would theoretically lead to overestimating the likelihood of improbable threat. The links between these constructs and OCD have typically been validated in separate studies using different measures, making it difficult to determine just how distinctive these constructs are from each other. For the sake of clarity however, I will review each of them separately using names and definitions they have been designated in their respective literatures.

Doubt. In the context of OCD, doubt is typically referred to as to a lack of subjective certainty about one's perceptions and internal states (Lazarov, Dar, Liberman, & Oded, 2012). As such, heightened doubt should result not in global overestimations of threat probability, but rather a more specific

difficulty with appraising highly improbable events as certain not to occur. Because of this, doubt arguably provides a compellingly parsimonious explanation for how thosewith OCD could (at least slightly) overestimate the likelihood of improbable events specifically.

Although clinicians have long acknowledged the role of excessive doubt in OCD (Gerrios, 1989; James, James, Burkhardt, Bowers, & Skrupskelis, 1890; Janet & Raymond, 1903), even referring to it as "the doubting disease" (Ciarrocchi, 1995; Ceflau, 2010), this link was not formally evaluated until relatively recently. Specifically, Samuels et al. (2017) had clinicians rate the doubt severity (0 = "none", 5 = "extreme and debilitating") of 1132 OCD patients based on their responses to a single doubt-specific question: "After you complete an activity, do you doubt whether you completed it correctly?'. The mean number of OCD symptoms increased with the degree of doubt for each of the major OCD symptom dimensions (checking, contamination, symmetry/ordering, hoarding), and OCD-related impairment was uniquely predicted by doubt as well. Notably, the likelihood of GAD and the number of anxiety-related personality diagnoses (e.g., avoidant personality disorder) also increased with levels of doubt. However, every one of these participants also had an OCD diagnosis, so it is unclear whether elevated doubt would also be present in participants who had GAD or an anxiety-related PD but not also OCD.

Another common method for assessing doubt in OCD is through examining whether OCD patents exhibit reduced confidence in their cognitive

abilities. The most consistent effects within this domain have been found for memory (e.g., Constans, Foa, Franklin, & Matthews, 1995), particularly in OCD-relevant situations involving potential mistakes (e.g., Cougle, Salkovskis, & Wahl, 2007) and particularly for participants with primary checking symptoms (Macdonald, Antony, Macleod, & Richter, 1997). This reduction in memory confidence is typically greater compared to that of anxious control participants (Tolin et al., 2001), though this difference may partly be the result of utilizing OCD-relevant content in the experimental manipulation (Hermans, Martens, De Cort, Pieters, & Eelen, 2003). Importantly, OCD participants typically report reduced confidence in memory despite demonstrating intact abilities during both recognition and recall tasks (Hermans et al., 2003; Macdonald et al., 1997).

A similar pattern of results has also been found for other cognitive domains. For instance, individuals with OCD may show intact or superior performance on a test of general knowledge compared to healthy and anxious controls, but reduced confidence in the correctness of their answers (Dar, Rish, Hermesh, Taub, & Fux, 2000). Similarly, OCD participants may exhibit less confidence in the ability to maintain attention relative to both healthy anxious control participants, with levels of mistrust specifically predicting levels of checking symptoms (Hermans et al., 2008).

Indecisiveness. In addition to manifesting as reduced confidence in one's cognitive faculties, doubt in OCD is also believed to manifest as indecisiveness, which some researchers propose is actually indistinguishable

from doubt (Nestadt et al., 2016). One of the first studies to systematically establish this indecisive tendency in OCD was conducted by Fear and Healy (1997). Specifically, these researchers tasked participants with deciding whether a ball was beingdrawn from two different urns: one with a 85:15 mixture of red to black balls (Jar A) and another with a 85:15 mixture of black to red balls (Jar B). The authors found that OCD participants required significantly more draws to decide upon which jar they were drawing from (3.4 draws) compared to healthy control participants (2.6 draws), participants with delusional disorders (1.5 draws), and participants with mixed obsessive and delusional features (2.7 draws). In a second, subsequent condition, balls were repeatedly selected from Jar A by the researcher and participants rated the chance that the balls were coming from Jar A after each draw. Here, OCD participants required significantly more draws to reach certainty (7) compared to the delusional disorder group (3.1), the healthy control group, (3.4), and the mixed group (4.8). Importantly, these authors also provided a Bayesian estimate of the 'true' conditional probability that the observed set of balls were actually coming from Jar A. By draw three, the probability that the balls were coming from Jar A already had a Bayesian probability of 99%, suggesting that OCD participants were less able to treat the extremely improbable possibility that the balls were coming from Jar B as a certainty. These results were later replicated in a subsequent study, whichshowed that OCD participants also require more draws to a make a decision in this task compared to those with GAD (Pélissier & O'Connor, 2002).

In another study of doubt-related indecisiveness, Foa et al. (2003) had participants chose between two options in three scenarios: An OCD-relevant scenario (choosing a brand of gas stove), a low-risk scenario (choosing a brand of car wax), and a high-risk scenario (choosing a treatment for seriously ill relative). Participants were initially presented with a piece of information outlining the pros and cons of both options (e.g., a consumer report indicating what percentage of customers chose car wax A over car wax B), and could request up to seven additional pieces of information (presented in a similar format) before choosing an option. Compared to a non-anxious control group, OCD participants required significantly more pieces of information to make a choice in the low risk and OCD-relevant scenarios but not in the high- risk scenario. These results were driven by the fact that that OCD participants and healthy controls both requested more pieces of information in the high-risk scenario. This same pattern was observed for reaction time: OCD participants took longer to decide whether to request more information in the low risk and OCD-relevant scenarios but not in the high-risk scenarios. This suggests that doubt-related elevations in OCD are apparent in low-risk situations with low severity (i.e., the low-risk scenario) and high severity (i.e., the OCD-relevant scenario), but not in objectively risky situations involving both higher probability and higher costs (i.e., the high-risk scenario).

Finally, researchers have also examined indecisiveness among OCD participants in the domain of perceptual decisions. Specifically, Banca et al. (2015) used a random dot probe experiment to assess differences in decision-

making processes between OCD participants and healthy controls. The dots moved under across the screen at varying levels of coherence, which the authors broke down into three levels of uncertainty: high (2.5% - 5% of dots moving in a coherent direction), medium (15% - 25% of dots moving in a coherent direction), and low (45% -70% of dots moving in a coherent direction). One of the major findings was that OCD participants (relative to controls) had slower *drift rates*— a computationally derived parameter reflecting the speed of evidence accumulation during the decision process—specifically in conditions of low and medium uncertainty. In other words, OCD participants had a significantly more difficult time committing to choices when correct options were more obvious. This finding mirrors those of the studies described above and is consistent with doubt differentiating OCD individuals from unaffected person specifically in situations where the probability of making theincorrect choice is low. Interestingly, these researchers found that by yoking increased decision times to a cost (i.e., choices made after a certain amount of time would be penalized) OCD participants were able to make choices in low uncertainty conditions with less evidence, indicating their indecisiveness can be attenuated using incentives.

Inferential confusion. A related but distinct construct from doubt is a reasoning error known as *inferential confusion* (Emmelkamp & Aardema, 1999; Aardema, O'Connor, Emmelkamp, Marchand, Todorv, 2005), which refers to the tendency to confuse an imagined possibility with an actual probability. According to the authors, inferential confusion arises in OCD as a

result of engaging in inductive as opposed to deductive reasoning when judging a stateof affairs. For instance, while unaffected individuals may start with evidence and reason toward a conclusion (e.g., “I forgot to lock the door yesterday and was in a rush today [evidence], so maybe I forgot to lock the door today as well [conclusion]” individuals with OCD may begin with the conclusion and then search for evidence to disprove it (i.e.., “I forgot to lock the door today [conclusion], how can I be sure that I didn’t? [evidence]”). Because sensory evidence is incapable of disproving an abstract conclusion, the original doubting inference will persist produce anxiety and ultimately motivate maladaptive behavior (e.g., going back to check if the door is locked). In this way, inferential confusion is particularly relevant for explaining how those with OCD could be anxious about possibilities that are remote but cannot be technically disproven, thereby providing an additional mechanism by which risk for these low-probability scenarios could be slightly overestimated.

Links between inferential confusion and OCD have been found in both correlational andexperimental studies. Correlational studies have focused on assessing relations between OCD symptoms and scores on the Inferential Confusion Questionnaire (ICQ; Aardema et al., 2005), which was designed to measure the two tendencies deemed central to the construct: Inverse inference (e.g., “I often know a problem exists even thought I don’t have actual proof”) and distrust of the senses (e.g., “I am sometimes more convinced by what might be there than by what I actually see”). In a non-clinical sample, the authors found that the predecessor of the ICQwas positively correlated with

most forms of OCD as measured by the Padua Inventory, even while controlling for depressive symptoms (Emmelkamp & Aardema, 1999). Aardema et al. (2005) later replicated these results in a clinical sample, showing that a) individuals with OCD exhibited greater scores on the ICQ than anxiety disordered and healthy control participants, b) the ICQ positively predicted most OCD symptoms on the Padua Inventory except for 'dressing/grooming symptoms and 'impulses about harm', and c) the ICQ continued to uniquely predict levels of OCD symptoms even after controlling for all other belief domains from the OBQ-44 (e.g., importance of controlling thoughts, overestimation of threat, perfectionism, etc.).Interestingly, ICQ scores among those with delusional disorders and OCD did not significantly differ in this study, indicating inferential confusion may be an area of overlap between the two types of conditions.

In a follow-up study, Aardema, Radomsky, O'Connor, and Julien (2008) attempted to further characterize relations between inferential confusion and other common OCD beliefs by determining the factor structure of a combined questionnaire consisting of the OBQ-44 and ICQ.Interestingly, 14 of the 15 items from the ICQ loaded on a factor consisting mostly of items from the threat overestimation subscale of the OBQ-44. Moreover, after controlling for general anxiety and distress, the combined inferential confusion/threat overestimation factor was the onlybelief domain to significantly predict two separate indices of OCD symptoms and the only domain to predict every individual OCD symptom subscale. These same findings were also replicate by

the authors in three additional studies (e.g., Wu, Aardema, & O'Connor, 2009; Aardema et al., 2010); Polman, O'Connor, & Huisman, 2011). Thus, there is clear conceptual and empirical overlap between the tendency to engage in inferential confusion and the tendency to overestimate threat, which also appears to be a fairly central and specific feature of OCD pathology compared to other belief domains.

This same group has also tested the relevance of inferential confusion to OCD via experimental studies. Specifically, Aardema, O'Connor, Pélissier, and Lavoie (2009) assessed the degree to which estimates regarding the probability of a hypothetical state of affairs— whether one had hit a pedestrian with their car after hearing a scream and feeling a bump in the road— are affected by both reality-based information (e.g., "you see a pothole in your rearview mirror") and possibility-based information (e.g., "The pothole may have not been deep enough tocause the bump"). Results show that while the presentation of reality-based information produced similar decreases in event likelihood estimates across OCD participants and unaffected individuals, presentation of possibility-based information resulted in inflated estimates of event probability for OCD participants. Of note, this difference did not translate to a non-OCD- relevant situation (determining if there was a bus strike). These results were later replicated in a follow-up study using two new hypothetical scenarios (judging the cleanliness of a $20 bill, judging whether a gas stove had been left on), in which similar albeit weaker effects for a non- OCD-relevant scenario were also found (Nikodijevic, Moulding, Anglim, Aardema, &

Nedelijkovic, 2015).

Other researchers have since contended that possibility-based effects for OCD participants can be more parsimoniously explained as a 'better safe-than-sorry strategy'. More specifically, presentation of information consistent with *threat* is predicted to result in those with anxiety disorders (including OCD) being less sure of their safety compared to healthy controls, regardless of whether such information is presented as a possibility or a sensory reality (Gangemi, Mancini, & Dar, 2015). Indeed, these researchers found that when the possibility- based information is framed as evidence supporting *safety* (e.g., "you don't see a pothole in the rearview mirror, but it may not be easily viewable from your mirror") the findings were reversed:reality-based (danger-congruent) information led to greater levels of doubt among OCD participants relative to controls. Thus, it could be the case that inferential confusion is only triggered (or becomes problematic) in the context of potential threats and is not a more global reasoning error that OCD individuals evidence in all situations.

Magical Ideation. Magical ideation (MI), referred to as the tendency to hold beliefs that defy culturally-accepted laws of causality, has also been proposed to be central cognitive feature of OCD (Amir, Freshman, Ramsey, Neary, and Brigidi, 2001). Inherent to the definition of MI is the tendency to feel at elevated risk for extremely improbable events, as improbable events would necessarily be ones that defy laws of causality. Thus, MI is another trait that could potentially help explain why those with OCD overestimate the likelihood of improbable events.

Links between MI and OCD have traditionally been examined using the Magical Ideation Scale (MIS; Eckblad & Chapman, 1983), which assesses the presence/absence of beliefs about a number of magical influences (e.g., thought transmission, spiritual influences, psychic energy). Using this scale, Einstein and Menzies found that OCD symptoms were significantly predicted by MIS scores in both a clinical sample (Einstein & Menzies, 2004a) and a non-clinical undergraduate sample (Einstein & Menzies, 2004b). In a subsequent study, these same researchers found that MIS scores were elevated in both OCD checkers and OCD washers relative to individuals with panic disorder and healthy controls (Einstein & Menzies, 2006), which was later replicated in a non-western Turkish sample (Yorulmaz, Onozu, & Gültepe, 2011). Notably, while a separate group replicated the finding that MIS scores were elevated in OCD participants relative to healthy controls, they failed to find significant differences in MI between OCD participants and those with GAD (West & Willner, 2011).

Levels of magical ideation do not appear to be evenly distributed across OCD symptom presentations. In the study by Einstein and Menzies (2006) for instance, compulsive washers showed higher MI compared to compulsive checkers. In a larger and more comprehensive study (N = 395 OCD patients) however, Tolin et al. (2001) found a somewhat different pattern: Participants with primary aggressive obsessions (which lumped ‘pure aggressive’ and ‘pathological doubting’ obsessions together) and religious obsessions reported significantly greater MI compared to those with primary contamination

obsessions, symmetry/ordering obsessions, and somatic obsessions. A similar pattern of findings was also obtained by Lee & Telch (2005), who found that schizotypal traits (which include magical thinking) predicted levels of *autogenous obsessions*, which includes reactions to internally generated repugnant thoughts (i.e., as in aggressive OCD, religious OCD, sexual OCD) but not *reactive obsessions*, which include distressing reactions to external stimuli (i.e., as in contamination, pathological doubting, symmetry/ordering). Thus, while results are mixed, magical ideation appears to be more specific to those with aggressive and religious obsessions, and perhaps sexual obsessions as well.

Thought-action fusion. A related but somewhat more specific construct relative to magical ideation is thought-action fusion (TAF), which reflects the belief that one's thoughts can influence the external world. TAF is typically measured with the Thought-Action Fusion Scale (TAFS; Shafran, Thoradson, & Rachman, 1996), which usually breaks into two distinct components: moral TAF, defined as the belief that thinking about an action is morally equivalentto performing it, and likelihood TAF, defined as the belief that thinking about a possibility increases the likelihood that it will occur. Thus, likelihood TAF (but not moral TAF) reflects a specific belief mechanism by which individuals could come to overestimate the likelihood of magical, improbable events.

In the initial TAFS study, OCD participants exhibited greater levels of moral TAF and likelihood TAF relative to healthy undergraduates (Shafran et al., 1996). Amir, Freshman, Ramsey, Neary, & Brigidi (2001) followed up on

these results using a larger undergraduate sample ($N = 424$) and a more fine-grained measure of TAF, which assessed participants' perception of whether their thoughts could increase a) the likelihood of causing positive events (e.g., friend/relative having a relaxing vacation), b) the likelihood of negative events (e.g., friend/relative being in a car accident), and c) the likelihood of *preventing* negative events (e.g.,friend/relative *avoiding* a car accident). While participants reporting high OCD symptoms evidenced similar moral TAF compared to participants reporting low OCD symptoms, the high OCD group evidenced higher likelihood TAF for negative events, positive events, and negative event prevention. Thus, this study suggested that links between OCD and TAF were more circumscribed to the likelihood-based manifestation.

Although there is a general consensus that TAF is relevant to OCD, it also does not appear specific to the illness. For instance, Abramowitz, Whitesie, Lyna, & Kalsy (2003) found that while OCD participants exhibited greater likelihood TAF (but not moral TAF) relative to participants with depression and social phobia, they were not significantly elevated relative to participants with GAD or PD. Moreover, when controlling for levels of trait anxiety and depression, differences between OCD participants and the depressed and social phobic groups were no longer significant. Similar results were also gleaned in a number of other studies, which again showed that while OCD participants reported greater TAF than healthy controls, they were not different from those with other anxiety disorders (O'Leary, Rucklidge, & Blampied, 2009; Rasin, Merckelbach, Muris, & Schmidt, 2001; Shirinzadeh,

Nateghian, & Goudarzi, 2010). Indeed, in one study, individuals with GAD exhibited *higher* TAF compared to those with OCD(Thompson-Hollands, Farchione, & Barlow, 2013).

Notably, it is unclear whether differences between those with OCD and other anxiety disorders differed according to the type of TAF. This point is especially relevant for the finding that those with GAD showed greater TAF than those with OCD. Specifically GAD patients often hold beliefs about the importance and positive effect of worries, and thus may believe that worries can *decrease* (rather than increase) the chance of a negative outcome. Additionally, most studies comparing OCD participants to anxiety control groups utilized participants with GAD, so this explanation applies readily to these findings as well. In lieu of more detailed TAF comparisons however, extant evidence remains equivocal as to whether likelihood-based TAF is specific to OCD.

Sympathetic magic. Another belief that may result in an overestimation of improbable threat likelihood is sympathetic magic (Nemeroff & Rozin, 1994). Sympathetic magic refers to implausible beliefs about how contagions are transmitted, such as the idea that contaminants transfer to novel mediums permanently and absolutely (e.g., “Even if I was hungry, I would not drink a bowl of my favorite soup if it had been stirred by a used but thoroughly washed flyswatter”; Haidt, McCauley, & Rozin, 1994). Thus, the construct may be particularly relevantfor explaining how those with contamination OCD overestimate improbable threats.

To my knowledge, sympathetic magic has only been examined in relation to OCD in twostudies. In the first study, Woody & Tolin (2002) found that OCD participants exhibited higher scores on the Sympathetic Magic subscale of the Disgust Scale (Haidt et al., 1994) relative to healthy controls but not anxious controls. The authors proposed that null difference between the OCD and anxiety group in this study were due to the content of sympathetic magic scale being too general relative to the concerns expressed by those with contamination OCD.

In the second study, the same authors tested this explanation by comparing OCD patientswith contamination obsessions to anxious- and non-anxious control participants on an experimental paradigm with greater relevance to contamination-specific beliefs in sympathetic magic (Tolin Worhunsky, & Maltby, 2004). In this paradigm, participants selected an object they felt was contaminated (e.g., piece of rotting food, a toilet, etc.) and then touched a clean pencil toit. Subsequently, the researchers thoroughly rubbed this 'contaminated' pencil to a second pencil, and then a third, a fourth, a fifth etc. up to 11 pencils to create a 'chain of contagion'. The authors repeated this same procedure in a control condition, where pencils were instead rubbed onto a neutral object (i.e., a piece of candy). Following each point of contact, participants rated how contaminated they believed the pencil was on a 0 – 100 scale (0% = "not at all contaminated", 100 = "completely contaminated"). While all groups showed a steep drop off in perceived contamination for pencils whose initial contact began with candy, the contamination manipulation

produced the expected group differences: Both control groups perceived pencils farther down the chain of contagion as gradually less contaminated, while OCD participants continued to rate pencils far removed from the original contaminant as markedly contaminated.

For instance, while both anxious and healthy control participants gave a rating of zero contamination by pencil #7, OCD participants continued to give a mean contamination rating of 50% by the last pencil (pencil #12). While it is unclear whether these differences are attributableto greater sympathetic magic beliefs per se, they did successfully illustrate how those with contamination OCD could overestimate the likelihood of improbable contamination-related events (e.g., contracting HIV from a doorknob).

Personal vulnerability. Finally, a more recent line of inquiry has suggested that individuals with OCD are also distinguished by a heightened sense of *personal vulnerability* forlow base-rate events. Specifically, several studies have shown that OCD participants judge the likelihood of improbable negative events (e.g., suffering from a life-threatening infection or unintentionally killing/severely injuring another person) greater than healthy controls, but only when such events are framed as occurring to *themselves* (Moritz & Jelineck, 2009; Moritz & Pohl, 2009; Niemeyer, Moritz, & Pietrowsky, 2013; Zetsche, Rief, & Exner, 2015). Thus, these studies perhaps most directly demonstrate that those with OCD overestimate their risk for experiencing highly unlikely threats.

Nonetheless, an issue with these studies is that their samples were

composed exclusively of OCD patients with washing- and checking-concerns, which matched the types of index eventsused in the study (i.e., contracting a harmful disease; hitting someone with your car). Thus, it is difficult to tell from this evidence alone if perceived vulnerability is generalizable to all improbable threats or specific to the consequences most relevant to these OCD subtypes. Moreover, evidence for the specificity of increased personal vulnerability in OCD is mixed, asthose with OCD show increased levels of the variable relative to other anxiety groups in some studies (e.g., Moritz & Jelinek, 2009) but not others (e.g., Zetsche et al., 2015).

Summary of improbable threat overestimation. Overall, the studies reviewed in the preceding section illustrate that there are a variety of traits and mechanisms that could theoretically result in individuals with OCD overestimating the likelihood of improbable events.The fact that these proclivities would lead to overestimating improbable events specifically is implied by both the face-valid conceptualizations of the traits and the nature of the experimental conditions that produced differences between OCD participants and controls. For instance, traits like thought-action fusion, magical ideation, and sympathetic magic are clearly relevant to improbable events specifically, as they refer to beliefs in phenomena that are not deemed possible in the physical world. Similarly, differences between OCD participants and healthy controls in indecisiveness tend to emerge most robustly in circumstances where the correct choice is obvious, implying that OCD participants continue to question the right decision even when the

probability of making the wrong choice is exceedingly low.

As mentioned earlier, it is difficult to assess the distinctiveness of OCD-relevant processes linked to the overestimations of improbable event likelihoods. For some traits, the conceptual overlap is clear: TAF and sympathetic magic, for instance, could be considered morespecific types of magical ideation. Similarly, indecisiveness could arise from doubting one's memory, attention, or knowledge. In line with these notions, Nestadt et al. (2016) suggested that these more specific processes are really just secondary manifestations of doubt, perhaps even idiosyncratic post-hoc justifications by OCD patients for why they tend to doubt their safety for certain negative events. Indeed, many of the traits/processes that result in overestimating improbable event likelihoods are linked to specific OCD presentations: Doubt in one's cognitive abilities (memory, attention, perception) has been most robustly linked to checking-related concerns; sympathetic magic is clearly most relevant to contamination OCD; and magical ideation/thought-action fusion is elevated most commonly among those with aggressive, religious, and perhaps sexual OCD. Thus, it is possible that each of these distinct traits/processesare really just a presentation-specific manifestations of the tendency to overestimate the likelihood of improbable events.

Importantly, while several distinct traits/processes may result in improbable threat likelihoods being overestimated in OCD, evidence also suggests that such overestimations are typically quite slight. For instance, compared to healthy controls, OCD participants rate their personal

vulnerability for catastrophic OCD-relevant consequences as only slightly greater (Moritz & Jelinek, 2009), doubt the veracity of their perceptions/cognitive faculties only slightlymore (Hermans et al., 2008), and judge likelihood of extremely improbable experimental outcomes as only slightly more uncertain (Fear & Vealy, 1996). Similarly, although OCD participants are often elevated on the TAFS and MIS, they do not report beliefs in the bizarre phenomena indexed by these scales as anything more than a possibility (e.g., Shafran et al., 1996). The notion that those with OCD only *slightly* overestimate the likelihood of improbable outcomes is also very consistent with the fact that most OCD patients possess intact insight into the senseless of their concerns (e.g., Marazzti et al., 2002; Kishore, Samar, Reddy, Chandrasekhar, & Thennarasu, 2004), and rarely appraise their feared consequences as very likely (Foa and Kozak, 1995; Tolin et al., 2001).

Finally, most of the reviewed processes and traits showed at least some evidence of specificity to OCD (e.g., they were elevated among OCD participants relative to anxious controls). There were some notable exceptions like elevated TAF in GAD, though this particular elevation could be due to a failure to consider the heterogeneity underlying measures of TAF. Regardless, the fact these constructs were most robustly linked to OCD suggests that overestimations of improbable threat likelihood are more relevant to OCD compared to other anxiety disorders.

Overestimation of catastrophic event costs in OCD

Although the tendency to overestimate the likelihood of improbable

events appear to play an important role in OCD, clinicians have suggested that overestimations of threat severity are also relevant to the illness. For instance, Van Oppen and Arntz (1994) and Salkovskis (1999) both noted that OCD patients may come to accurately appraise a feared consequence as very unlikely after therapy but still continue to obsess about it if they overestimate its potential severity. However, there is little evidence to suggest that any cost-related distortions associated with OCD would result in elevated perceptions of danger to catastrophic outcomes *specifically*. Thus, it does not seem plausible that cost-related distortions are capable of producing an OCD- relevant concern with improbable catastrophes on their own. Nonetheless, there are several well-known OCD-relevant traits capable of producing more general cost-related overestimations that warrant consideration given their potential for augmenting the perceived aversiveness of the catastrophic outcomes associated with SIC.

Inflated responsibility for harm. As reviewed earlier, inflated responsibility (IR) refers to a heightened belief about one's responsibility for harm or danger occurring to oneself or others. As such, IR could theoretically increase the aversiveness of a potential outcome (e.g., having one's house burglarized) by adding additional responsibility-related costs (e.g., feelings of guilt, fears of blame) to the more direct costs of the outcome (e.g., the loss of possessions). Indeed, experimental manipulations of IR has been shown to specifically produce elevations in perceived threat *severity* as opposed to increases in perceived threat probability. For instance, Menzies, Harris, Cumming, & Einstein (2000) found that undergraduates with OCD rated the

severity (but not likelihood) of hypothetical washing- and checking-related situations greater than healthy controls, but only in scenarios where the participant would have been responsible for the aversive outcome.

Much of the early research on IR validated its role in OCD. For instance, several studies demonstrated that pathological beliefs about responsibility for harm were higher among OCD participants relative to healthy and anxious controls (Salkovskis, et al., 2000; Cougle, Lee, Salkovskis, 2007). In another study, levels IR were found to significantly predict OCD symptoms controlling for other OCD-relevant traits (e.g., Rhéaume, Freeston, Dugas, Letarte, &Ladouceur, 1995). The relevance of IR to OCD is also underscored by the decision of the OCCWG to list the construct as one of the core beliefs associated with OCD (OCCWG, 2003) and by its centrality to early etiological conceptualizations of the illness (Salkovskis, 1996).

The relevance of IR to OCD is further demonstrated by the ability of experimental responsibility manipulations to elicit increases in OCD-like symptoms. In such experiment, participants were presented a low-responsibility scenario (e.g., “You see a piece of string on the ground”), an OCD-relevant responsibility scenario (e.g., “You see some nails on a road”), and a high-responsibility scenario (e.g., “You see a person sitting alone in a diner is choking”). Similar to results from a similar study with this design (i.e., Foa et al., 2001), significant differences emerged on low-responsibility and OC-relevant scenario but not on high-responsibility scenarios: OCD

participants (relative to healthy and anxious controls) reported greater distress atleaving these situations unrectified, a greater desire to rectify them, and greater responsibility if aconsequence were to occur as a result of not rectifying them (Foa, Amir, Bogert, Molnar, & Przeworski, 2001). In a replication and extension of this experiment, Foa, Sacks, Tolin, Prezworski, & Amir (2002) found the same pattern of results for OCD participants with primarychecking symptoms but not for OCD participants with different primary symptoms.

Another type of experimental responsibility manipulation was conducted by Arntz, Voncken, & Goosen (2007). These researchers had participants sort pills of 11 different color combinations into appropriate jars in a low responsibility condition, where participants thoughtthey were helping with a study of visual color perception, and a high responsibility condition, where participants thought they were validating a pill-sorting scheme to aid with medication dispensation in 3rd-world country that had previously been rejected because of too many participant errors. Participants were coded by raters for 'compulsive-like' checking behaviors such as re-checking that pills had been correctly sorted or pausing to inspect the pill's color.

Results showed that, relative to both anxious and healthy controls, OCD participants exhibited more checking behaviors in the high-responsibility, but not low-responsibility condition. As such, this study extended the results of previous IR experiments by demonstrating that increases in perceived responsibility could also induce greater compulsive behaviors (i.e., checking)

among OCD participants in the laboratory.

Although both correlational and experimental work leaves little doubt that IR is relevant to OCD, other studies have implicated this construct as a more general marker of anxiety pathology. For instance, in a study by Tolin et al. (2006), IR was the *only* OCD-relevant belief that was *not* elevated among OCD participants relative to anxious controls, even when trait anxiety and depression were controlled for. More recently, Pozza & Dèttore (2014) conducted ameta-analysis demonstrating that relations between OCD symptoms and IR were strong, (r = .42), but not stronger relative to its relations with other anxiety symptoms. As such, it appears that while IR is relevant to OCD, the construct may also produce cost-based overestimations among those with other forms of anxiety pathology.

Intolerance of Uncertainty. In the context of OCD, Intolerance of Uncertainty (IU) is defined as the belief that uncertainty, newness, and change are intolerable because they are potentially dangerous. Thus, IU is another trait that could theoretically augment the perceived severity of an aversive consequence by supplementing an event's direct consequences with additional uncertainty-related discomfort.

Although early research implicated IU as a sensitive and specific feature of OCD (Steketee, Frost, & Cohen, 1998), latter research suggests the trait is actually elevated across many forms of anxiety pathology. Specifically, Tolin et al. (2003) found that, although IU was significantly elevated OCD patients relative to anxious controls initially, the difference disappeared when

levels of trait anxiety and depression were controlled for. Other studies have since yielded similar results (e.g., Mahoney & McEvoy, 2012; Boswell, Thompson-Hollands, Farchione, & Barlow, 2013). Indeed, a recent meta-analysis found that when a more general, non-OCD-specific definition of IU is used (Buhr & Dugas, 2009), the construct is actually more related to symptoms of GAD than to symptoms of OCD (Gentes & Ruscio, 2011).

In addition to the fact that IU may not be specific to OCD, the trait also does not appearrelevant to all OCD presentations. For instance, Tolin, Abramowitz, Brigidi, and Foa (2003) found that IU was elevated among OCD checkers but not OCD patients without checking. Similar results were obtained by Julien, O'Connor, Aardema, and Todorov (2006) who foundthat a combined IU/perfectionism scale uniquely predicted symptoms related to checking and precision but not other types of OCD symptoms. Thus, although IU may result in cost-related overestimations for some OCD patients, its effects may not be generalizable to all OCD subtypesor specific to the disorder as a whole.

Perfectionism. A final OCD-relevant trait that may augment the cost of aversive consequences is perfectionism, defined as the tendency to set high standards and employ critical self-evaluations (Frost & Marten, 1990). As such, perfectionism may render consequences more subjectively aversive by causing the individual to perceive unfortunate events as evidence of personal failings, which may open them up to criticism by others (McFall & Wollersheim, 1979). Indeed, researchers have specifically conceptualized perfectionism as a construct that elevates the subjective cost of negative events in OCD (McFall &

Wollersheim, 1979)

Links between perfectionism and OCD have been well-studied. In one of the first studiesof this topic, Rhéaume, Freeston, Dugas, Letarte, and Ladocuer (1995) found that levels of perfectionism as measured by the Multidimensional Perfectionism Scale (MPS; Frost et al., 1990) was a unique predictor of OCD symptoms in a non-clinical student samples, even when beliefs pertaining to inflated responsibility were controlled for. This result was later replicated and extended to show that perfectionism uniquely predicted OCD symptoms controlling for bothinflated responsibility and beliefs about perceived danger (Rhéaume, Ladouceur, & Freeston, 2000). Similar findings were also obtained in a separate group utilizing a different perfectionism scale, which also showed that OCD symptoms were uniquely related to 'maladaptive perfectionism' (i.e., constant dissatisfaction at failing to meet one's personal standards) but not 'adaptive perfectionism' (i.e., constant motivation to grow and improve; Rice & Pence, 2006).

Clinical studies of OCD and perfectionism have since demonstrated that the relationship between these variables is more nuanced than was implied in previous non-clinical studies. In thefirst of these studies, Frost and Steketee (1997) found that OCD patients were only elevated on two perfectionism domains relative to healthy controls: Concern Over Mistakes (e.g., "If I fail at work/school, I am a failure as a person") and Doubt (e.g., "I usually have doubts about the simple everyday things I do"). Further, these same researchers found differences between OCD patients and anxious controls on the doubt

subscale, but not the Concern Over Mistakes subscale.Importantly, the Concern Over Mistakes subscale arguably better taps the tendency to overestimate the *cost* of negative events, whereas the Doubt subscale appears to more tap the tendency to overestimate the *probability* of negative events. Thus, this study suggested that the perfectionistic tendencies toward overestimating threat-related costs are not specific to OCD. More conclusive evidence for this assertion came from a recent meta-analysis examining the roleof perfectionism in anxiety disorders, OCD, anorexia, and depression (Limburg, Watson, Hagger, & Egan, 2017). In this study, doubt was once again the perfectionistic domain that was most strongly related to OCD symptoms, while associations involving 'concern over mistakes' were more or less equivalently associated with OCD symptoms (r = .37) and other anxiety symptoms (r = .34) and even more strongly associate with depression symptoms (r = .45).

Finally, like other cost-related distortions, there is some evidence that perfectionism has distinct relationships with different OCD symptoms. In one study, Martinelli et al. (2014) found that doubt about performing actions was a significant predictor of checking symptoms, while the perfectionistic domain of organization (e.g., "Organization is very important to me") specifically predicted ordering symptoms. Similar results were found by Wheaton et al. (2010), who found that perfectionism as measured by the OBQ-44 specifically predicted symmetry obsessions. Likewise, Tolin, Brady, and Hannah (2008) found that perfectionism from the OBQ predicted scores on the Obsessing, Hoarding, and Ordering scales of the OCI-R. In sum, perfectionism

appears to be another cost-related distortion that is both not specific to OCD and not pervasiveacross all OCD symptoms domains.

Characteristics of improbable catastrophes as evidence for particular threat-based distortions

To complement the empirical evidence used to elucidate the origin of SIC, I would like to briefly turn to how the theoretical properties of improbable catastrophes also help clarify the nature of this sensitivity. To illustrate, consider the decision to prevent a prototypical OCD- relevant improbable catastrophe—re-checking the stove to prevent a fire—through the lens of an expected value calculation (i.e. value = likelihood x cost), where checking has an objective cost of -1 and a probability of 1, and losing one's house to a fire (given that one checked) has an objective cost of -100,000 and an objective probability of .000001, making checking the favored option (i.e., [Checking: -1 x 1 = -1] < [Not Checking: -100,000 x .000001 = 0.1]). Next, consider what degree of probability- and cost-based overestimations would be necessary to make*checking* the favored option. For checking to become the favored option purely through a probability-based distortion, just a *slight* overestimation is necessary (e.g., p = .0001 rather than p = .000001; -1 > - 10[-100,000 x .0001]). This minor distortion is consistent with most OCD patients possessing intact insight into the senselessness of fears (Foa & Kozak, 1995; Marazziti et al., 2002; Kishore et al., 2004), as well as with experimental evidence suggesting that likelihood estimates of catastrophic outcomes among those with OCD are

only slightly higher than healthy controls (e.g., Moritz & Jelinek, 2009).

In contrast, for checking to become the favored through a purely cost-based distortion, an *excessive* overestimate is required (e.g., c = 10,000,000 rather 100,000; -1 > - 10[-10,000,000 x .000001]). Given that this consequence is objectively terrible, it is hard to envision what additional costs the person could imagine for the idea of not checking to be considered 100 times more aversive. The issue with explaining SIC using only a cost-based distortion is further compounded by the fact that many OCD-relevant fears are so improbable that they may be considered to have an objective probability of zero (e.g., catching HIV from a doorknob; catching undesirable qualities from another person). As such, *no degree* of cost-based overestimation would be sufficient to elicit compulsive behavior in the absence of a probability-based distortion. In this way, probability-based distortions offer a more likely pathway for the development of SIC, as such overestimations are theoretically more capable of eliciting compulsive avoidance of improbable catastrophes among those with OCD.

Still, even though cost-based distortions seem incapable of explaining the development ofSIC on their own, they could still *exacerbate* OCD symptoms by rendering the perceived consequences of a feared outcome more severe. For instance, Oppen and Arntz (1994) suggest that cost-related distortions like inflated responsibility may continue to drive compulsive behavior among OCD patients after EX/RP has significantly reduced one's probability-based overappraisals of danger. The influence of cost-related

distortions may be especially relevant for less objectively severe consequences (e.g., yelling profanities in church), which arguably leave far more room for the individual to conceive additional consequences (e.g., total dismissal by church community) that may result in those outcomes being perceived as *subjectively* catastrophic. Importantly, the notion that traits linked to cost-based distortions are symptom exacerbating factors is consistent with empirical data showing these overestimations are relevant to OCD while not being central or specific markers of the disorder.

Conclusions: The Present Dissertation

Overall, evidence from past literature—whether it be phenomenological, lab-based, orcorrelational—suggests that OCD may involve an underlying sensitivity toward improbable catastrophes (SIC). Similar types of evidence suggest that SIC is fairly specific to OCD and is likely driven primarily by a tendency to overestimate improbable event likelihoods rather than a tendency to overestimate catastrophic event costs. However, no studies to date have attempted toexperimentally validate these claims. In this dissertation, I will attempt to address this important gap by testing how OCD symptoms predict responding to threats parametrically varying in probability and perceived aversiveness.

In the first study, I will test the hypothesis that OCD symptoms predict anxious reactivity(subjective anxiety ratings, fear-potentiated startle responses, behavioral avoidance choices) to improbable, highly aversive threats, as well as heightened likelihood estimates to improbable threats in general. In the second

study, I will test whether these results are invariant across harmful and disgust-related threats, given the relevance of both types of consequences to common OCD presentations. In the final study, I will test whether heightened likelihood estimates for improbable threat, and heightened anxious reactivity to improbable, highly aversivethreat, can longitudinally predicts future levels of OCD symptoms during a stressful transition (i.e., 1st year of college), thereby clarifying whether SIC constitutes a risk factor or correlate of OCD. Across these studies, I will assess the specificity of SIC by testing whether predicted effects with OCD symptoms are shared with more general anxiety-related traits (i.e., trait anxiety) and symptoms (i.e., GAD and SAD symptoms). Together, these studies should help clarify whether SIC is a sensitive and specific feature of OCD which arises from a more general tendency to overestimate the likelihood of improbable threats.

Chapter 2: Methods Overview

The purpose of this chapter is to discuss the overarching methodological features of thedissertation. In particular, I will describe and justify my decision to a) assess OCD symptoms using the Obsessive-Compulsive Inventory-Revised (Foa et al., 2002), b evaluate responses to improbable catastrophes with an adapted version of the Pavlovian and Instrumental Generalization Paradigm (Van Meurs, Wiggert, Wicker, & Lissek, 2014) and, c) test relations between these variables in nonclinical samples of college students.

The Obsessive-Compulsive Inventory Revised

The Obsessive-Compulsive Inventory Revised (OCI-R; Foa et al. 2002) is an 18-item OCD self-report scale based on the original 42-item Obsessive Compulsive Inventory (Foa, Kozak, Salkovskis, Coles, & Amir, 1998). The OCI-R uses a 5-point Likert scale to assess how *distressed* or *bothered* individuals have been by 18 common obsessive-compulsive symptoms over the past month. In addition to a total score, the OCI-R yields subscales scores for six types of specific OCD symptoms: Washing (e.g., I sometimes have to wash/clean myself because I feelcontaminated), Checking (e.g., “I repeatedly check gas and water taps and light switches after turning them off”), Ordering (e.g., “I get upset if objects are not arranged properly”), Neutralizing (e.g., “I feel I have to repeat certain numbers”), Obsessing (e.g., “I frequently get nasty thoughts and have difficulty getting rid of them”), and Hoarding (e.g., “I have saved up so many things that they get in the way”).

In general, the OCI-R has been shown to possess excellent psychometric properties. In the validation study by Foa et al. (2002), the OCI-R showed excellent internal consistency acrossparticipants with OCD, social phobia, and PTSD, and no diagnosis, and all subscales had internal consistencies that were either good or excellent. Test-retest reliability for the full scale was good for both OCD patients and healthy controls, good-to-excellent for OCD participants for the subscales, and adequate-to-good for healthy controls for the subscales. The full scale also showed strong convergent/divergent validity as demonstrated by stronger relations with other OCD symptom scales compared to ratings of depression. Regarding means and cut-off scores,Foa et al. (2002) found that OCD patients had a mean score of 28 compared to approximately 18.82 in a sample of university students, and that a score of full-scale score of 21 was best at discriminating the two groups (sensitivity = 65.6%; specificity = 63.9%). Of note, university students were not screened for the presence of OCD, so it is possible that the specificity is actually higher than this value indicates. Scores on each OCI-R subscale were also elevated in OCD patients relative to university students with the exception of Ordering, which was equivalent across the two groups, and Hoarding, which was actually *higher* in university students.

Abramowitz and Deacon (2006) conducted a follow-up validation study of the OCI-R, finding again that the instrument demonstrated excellent psychometric properties. Additionally, these authors found that OCD participants clustered into a particular symptom category on the Y-BOCS

showed theoretically-consistent elevations on the same OCI-R subscale (e.g., those in the symmetry cluster showed higher scores on the Ordering subscale of the OCI-R). This suggests that the OCI-R subscales are indeed a valid way to differentiate individuals on the basis of their OCD symptoms. The Neutralizing subscale emerged as the sole exception in these analyses, as it was elevated equally across several distinct OCD symptom groups.

In summary, the OCI-R appears to be a well-validated and psychometrically sound instrument with which to assess OCD symptoms in a convenient format. The subscales seem to possess less desirable but nonetheless valid properties compared to the overall scale. The largest concerns lie with the reliability and validity of the Neutralizing scale. There may also be concerns with the Hoarding subscale, which appears to poorly discriminate individuals with OCD given that it was actually higher in a putatively healthy sample of university students. Finally, the relatively poor sensitivity-specificity of the total score suggests that results with the continuous scale should not be over-interpreted as a way of determining the presence/absence of an OCD diagnosis.

The Pavlovian and Instrumental Generalization Paradigm

The Pavlovian and instrumental Generalization (PIG) paradigm is a fear learning and decision-making task developed by Van Meurs, Wicker, Wiggert, and Lissek (2014). In this experiment, both the fear-learning and decision-making components of the task take place withina virtual farmer computer game during which the participant is a farmer tasked with traveling between a

shed and garden to successfully harvest crops (see Figure 2.1 below). During the journey to the garden, participants may receive electric shock depending on a) the road taken to reach the garden, and b) the shape presented in the center of the screen. One road (the short road)is contingently associated with shock but ensures a successful harvest (i.e., 100% of a win), while another road (the long road) is never associated with shock but only leads to a successful harvest 25% of the time. Even when traveling the short road, electric shock only occurs when specific shape known as the conditioned danger cue (CS+) is presented, which is counterbalanced so as to be the largest ring for half of participants and the smallest ring for the other half.

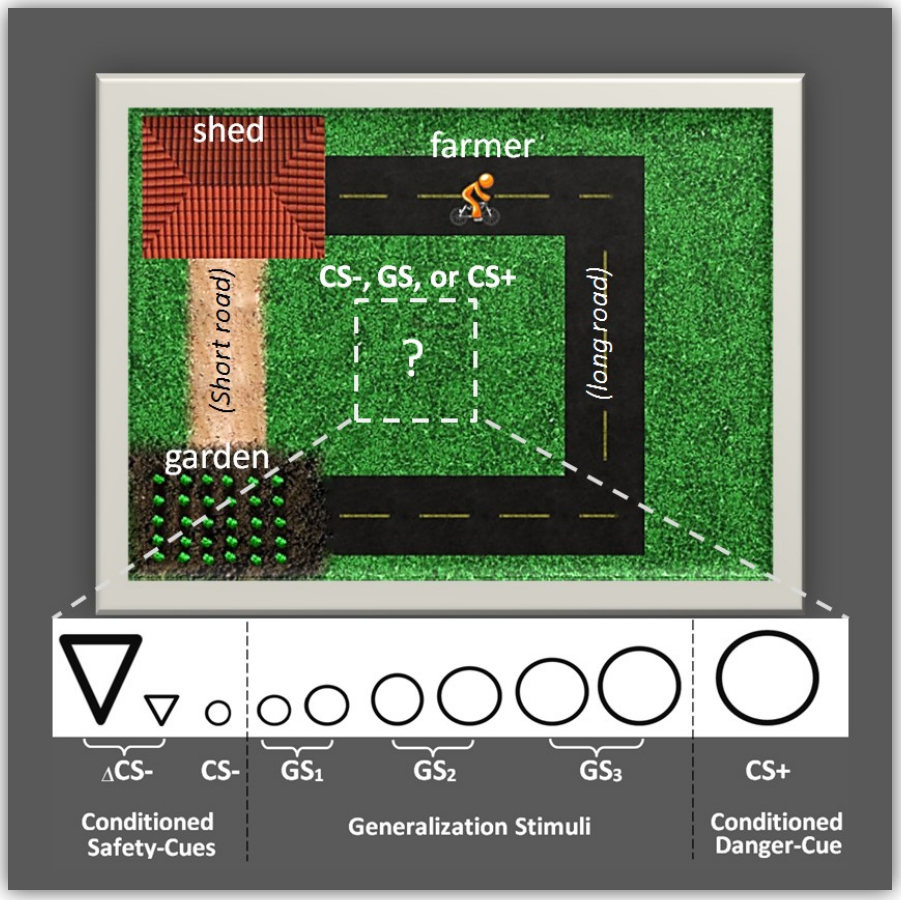


Figure 2.1. Picture of the virtual farmer computer paradigm displaying the short and long roads connecting the tool shed to the garden. Also pictured are the conditioned stimuli presented in the center of the screen during the task.. The diameters of rings from smallest tolargest are .8", .96", 1.12", 1.28", 1.44", 1.60", 1.76", 1.92" (size increases were established in 20% increments). Width and height are .8" for the small triangle, and 1.92" for the large triangle; in the present dissertation, these triangles sizes were averaged to form one medium-sized triangle that served as the triangular safety cue. CS- = conditioned safety cue; GS = generalization stimulus; CS+= conditioned danger cue; ΔCS-= triangular conditioned safety cue; GS_1, GS_2, GS_3 = generalization stimulus classes 1-3.

The PIG paradigm consists of two types of trials: Pavlovian and instrumental trials. On Pavlovian trials, participants are automatically sent down a short road to plant their crops, duringwhich startle-blink electromyography (EMG) is recorded and participants report subject ratings of perceived risk by responding to the question, "Level of risk?", on a 3-point scale (1 = "no risk", 2 = "some risk", 3 = "high risk"). The startle reflex is evoked by startle probes administered 2.5 or 3.5 s post-trial onset (18-22 s inter-probe interval [IPI]) while startle-blink electromyography (EMG) is recorded. On instrumental trials, participants can choose to harvest their crops by taking either the short road or the long road described above during a 5s deliberation period; failure to choose a road within the 5s interval results in the farmer being automatically sent down the short path. Importantly, decisions to choose the long road in the absence of the CS+ may be considered maladaptive as task performance is unnecessarily compromised in the absence of genuine danger (i.e., shock will not actually occur). Throughout the experiment, the CS+ (but no other shape) is paired with a brief electric shock to the left wriston 50% of Pavlovian trials and 100% of instrumental trials where the short road is

taken. Travel down both the short and long roads on instrumental trials are 8 s in duration.

The PIG paradigm consists of three phases: Preacquisition, Acquisition, and Generalization. Since fear generalization is not of interest to the current studies, the generalization phase will heretofore be referred to as the 'Test Phase'. All trials during Preacquisiton and Acquistion are Pavlovian trials involving three different stimuli: A large ring, a small ring, and a triangle. During the Test Phase, participants experience alternating Pavlovian trials (identical structure to the first two phases) and instrumental trials, which involve both the three stimuli from the first two phases and a number of new stimuli, which are ring sizes forming three classes of generalization stimuli (GSs: GS_1, GS_2, GS_3). Together, such stimuli form a continuum of perceptual similarity to CS+, going from CS+ to GS_3, to GS_2, to GS_1, to CS-, to ΔCS- (see Figure 2.1 above).

To ensure an even distribution of trial types, both Pavlovian and instrumental trials are arranged in blocks, within which stimuli are presented in quasi-random order such that no morethan two stimuli of the same class occur consecutively. Preacquisition consists of two blocks, each containing two ΔCS-, two CS-, and two CS+; Acquisition consists of four blocks, each containing two ΔCS-, two CS-, and two CS+; Test consists of six blocks, each containing two ΔCS-, two CS-, two GS_1, two GS_2, two GS_3, and two CS+.

Past studies of PIG

All three extant studies of the PIG paradigm (van Meurs et al., 2014;

Hunt, Cooper, Hartnell, & Lissek, 2017; Hunt, Cooper, Hartnell, & Lissek, 2019) indicate that participants display levels of conditioned fear and avoidance in a manner consistent with the presented stimulus. Specifically, results from each study show a continuous decline in startle EMG, online risk ratings, and avoidance choices as stimuli become more dissimilar from the CS+. Moreover, while the correlation between fear and avoidance measures on the PIG is significant, these measures are far from redundant. Indeed, two of the three studies on the PIG paradigm have beendedicated to identifying personality factors that can explain the large amount of variance in avoidance that is left unaccounted by fear-related measures (Hunt et al., 2017; Hunt et al., 2019).

Relevance of PIG for current studies

Although the PIG paradigm was developed as a measure of generalized fear and avoidance, it also possesses a number of properties that make it a desirable experiment for assessing threat responses to improbable catastrophes. The first desirable property of the PIG isthe way the task manipulates threat *probability*. Specifically, even though the CS+ is the only shape that is ever associated with shock, the perceptual similarity between it and other shapes provides a continuum on which safety from electric shock becomes gradually more certain.

Participants are tasked with estimating these probabilities themselves based on their past experiences with the shapes and are never given explicit information about how likely a shape isto result in shock. Accordingly, threat

during the PIG paradigm is encountered under conditions of *ambiguity,* where threat probability values are unknown, as opposed to *risk*, where threat probabilities are provided. This distinction is important for both empirical and ecological reasons: OCD patients consistently display suboptimal decision-making under conditions of ambiguity but not risk (Starcke, Tuschen-Caffier, Markowitsch, & Brand, 2010; Zhang et al., 2015; Kim et al., 2015) and real-world OCD-related consequences must be estimated in the absence of explicit probability information, as their base rates are often unknown (e.g., contracting HIV from public surface) or unknowable (e.g., going to hell for an immoral thought).

Another important property of the PIG's threat probability manipulation is the empirically-derived shape of its stimulus gradient. Specifically, participants appear to make a fairly clear distinction between the three shapes with the least similarity to CS+ (ΔCS-, CS-, GS_1) and the three shapes with the most similarity to CS+ (GS_2, GS_3, CS+): All shapes in the former group are rated significantly lower than shapes in the latter group, but are not rated as significantly different from each other (Hunt et al., 2017; Hunt et al., 2019). Moreover, the average risk rating for the group of shapes less resembling conditioned danger (i.e., ΔCS- CS-, GS_1) is close to zero, and when transformed from the three-point risk rating scale to a percentage comes but to an average threat probability rating of 5% (see Figure 2.2.A below). Thus, half the stimuli used in the Test phase may be considered an experimental analogue of the *extremely improbable consequences* that are observed across OCD's

major presentations.

The second important property of the PIG paradigm is the nature of its experimental threat. Namely, the intrinsically aversive nature of electric shock allows it to produce fairly high levels of anxiety across participants, especially given that it is calibrated to a standardized level meant to be “highly uncomfortable, but not painful” (van Meurs et al., 2014). To illustrate, the self-reported shock aversion ratings from Hunt et al. (2017) are shown below in Figure 2.2.B. These ratings reflect how averse participants were to the consequences of electric shock, which was assessed retrospectively with the question, “How important is it to you to not get shocked?” using a 10-point scale (0 = “none”, 10 = “extremely”). As shown in this figure, the ratings are more or less evenly distributed; however, the modal rating is still a 10/10. Thus, participants vary significantly in how aversive they find electric shock during the paradigm, but many find it maximally aversive. This aspect of electric shock is critical for ensuring the severity of the experimental threat is high enough to be considered a lab-based catastrophe for many participants who complete the task.

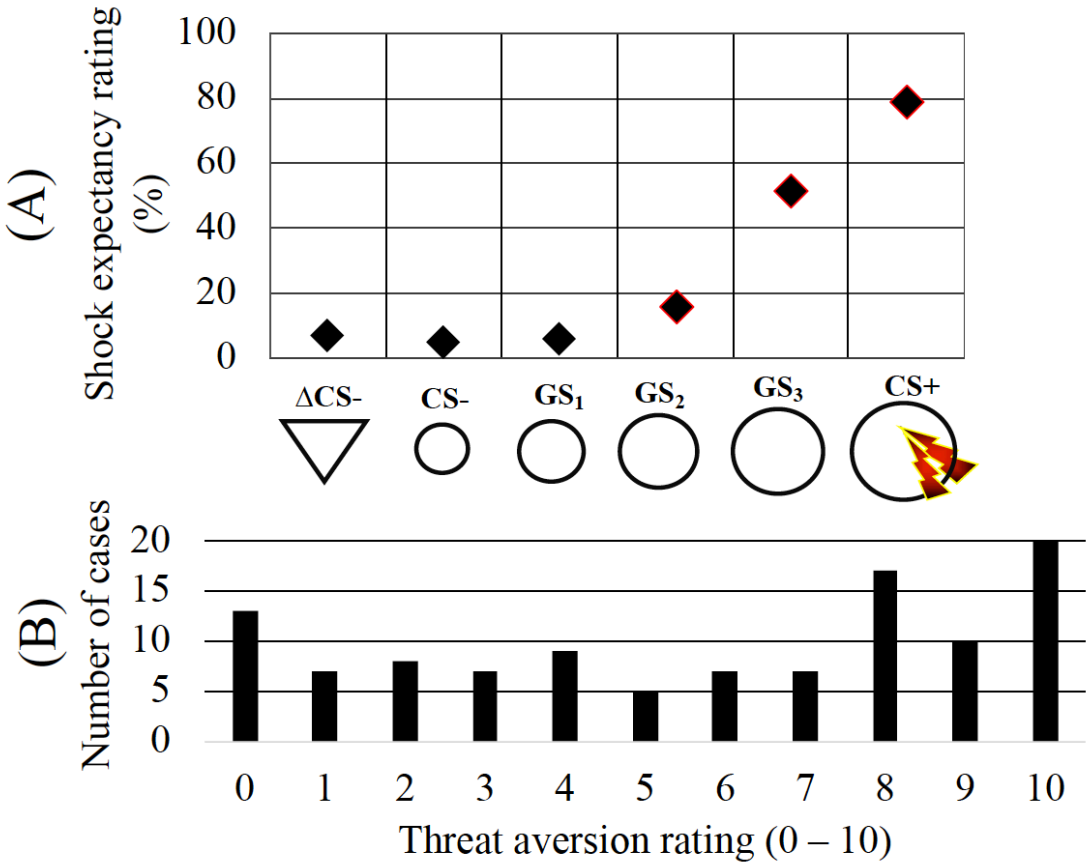


Figure 2.2. Response differences in terms of threat probability ratings (A) and threat aversion ratings (B) from a past study of the PIG paradigm (Hunt et al., 2017). Risk ratings were converted from a 0 – 2 scale to a 0 – 100 scale to facilitate interpretations in terms of threat probability. All stimuli with data points outlined in red were rated significantly higher than stimuli with data points not outlined red. Threat aversion ratings were elicited with the question "How important was it to avoid getting shocked?". PIG = Pavlovian Instrumental Generalization. ΔCS- = Triangular safety cue; CS- = circular safety cue; GS_{1-3} = Generalization stimulus 1 – 3;CS+ = Danger cue. N = 109.

In addition to producing high and variable levels of perceived threat severity, electric shock is desirable for the fact that it bears little to no direct relevance to OCD. Accordingly, any relations that are found between levels of OCD symptomology and threat responding in the PIG paradigm can be more readily attributed to the *features* of the experimental threat (i.e., its probability

and severity) as opposed to its particular *modality* (i.e., the fact that it involves electric shock). Critically, many past experimental studies that assessed relations between OCD and threat responses utilized threats commonly implicated in OCD (e.g., Moritz & Jelinek, 2009;Hermans et al., 2008), which made it difficult to conclude whether any response elevations to improbable catastrophes in these studies resulted from a more generalized sensitivity to such outcomes. The use of electric shock in the current studies should help circumvent this circularityand allow relations between OCD symptoms and responses to the lab-based improbable catastrophes be more readily attributed to SIC.

Conclusions

In summary, the PIG paradigm possesses a number of desirable properties that render it auseful tool for testing participants' general sensitivity to improbable, highly aversive outcomes. These strengths include the ambiguous nature of its threat, its lack of specific relevance to OCD,its ability to elicit varying levels of perceived threat severity and probability, and the large number of situations in which threats would (theoretically) be perceived as both improbable andhighly aversive.

OCD Symptoms in College Students

Although college students are a relatively cheap and convenient sample, there are understandably concerns about whether findings from this population generalize to other groups(Gordan, Slade, & Schmitt, 1987). Such concerns are arguably more relevant for mental disorders, where the group of

interest is not the population at large, but rather a relatively specific subset of individuals with the condition of interest. Thus, it is important to consider the potential limitations of evaluating OCD-relevant correlates in a university sample.

To assess the relevance of analogue studies in OCD, Abramowitz et al. (2013) outlines three conditions that must be met for findings of non-clinical samples to be generalizable: 1) The symptoms should be prevalent in the analogue population of interest, 2) the condition should be dimensional rather than categorical in nature, and 3) the disorder's symptoms should possess similar empirical features across clinical and nonclinical samples. I will next discuss how each ofthese conditions are met when it comes to generalizing findings with OCD symptoms in college students to individuals with clinical manifestations of the illness.

Regarding the first condition, researchers have long known that OCD symptoms are present among individuals without clinical levels of the illness. Rachman and de Silva (1978), for instance, showed that between 80-90% of people experience OCD-like intrusions at some point in their lives, a finding that has since been replicated numerous times (e.g., Freeston, Loaouceur, Thibodeau, & Gagnon, 1991; Purdon & Clark, 1993; Belloch et al., 2004). The non-clinical samples used to obtain these findings typically involve large proportions of college students; however, there is also direct evidence showing that OCD symptoms are prevalent specifically in college students. For instance, scores on the OCI-R from Foa et al. (2002) were actually higher

among college students compared to those from the anxious control group in the sample from Abramowitz and Deacon (2006). Similarly high elevations on the OCI-R have sincebeen found in other college samples (Hajcak, Huppert, Simons, & Foa, 2004; Sulkowski, Mariaskin, & Storch, 2011). Importanlty, there is also evidence supporting the idea that these elevations actually reflect clinical OCD. For instance, when Sternberger and Burns (1991) conducted a structured clinical OCD assessment with the top 3% of scorers on the Padua Inventory, 65% of participants met criteria for OCD.

Regarding the second condition, several studies have employed taxometric analyses (Waller & Meehl, 1998) to test whether OCD symptoms form distinct clusters or 'taxa', suggestive of categories, or are more continuous, suggestive of a dimension. In the first of these studies, Haslam, Williams, Kyrios, McKay, & Taylor (2005), examined the taxometric structure of the Padua Inventory, finding that two of its three symptom subscales (cleaning, checking) favored dimensionality, while the third (obsessional) exhibited more distinct high vs. low taxa. Of more direct relevance to the current studies was an investigation by Olatunji, Williams, Haslam, Abramowitz, and Tolin (2007), who subjected the OCI-R to taxometric analyses. These researchers found strong evidence of dimensionality for all six OCI-R subscales except hoarding,which showed evidence of high vs. low taxa.

Other evidence for dimensionality comes from studies of college students showing linearrelationships between OCD symptoms and indices of distress and functional impairment. For instance, Ching, Williams and Siev

(2017) found significant associations between violent obsessions and suicidal thoughts, while Mrdjenovich and Bischof (2003) found that higher MOCI scores were associated with lower grades despite individuals being enrolled in fewer courses. Additionally, Abramowitz et al. (2010) noted that across a meta-analysis of 51 studies comparing clinical OCD vs. non-clinical samples on the OCI-R, the standard deviation across both groups was largely similar. This also implies that OCD is dimensional, as it appears that therange of OCD-related impairment is similar across clinical and non-clinical populations alike.

Finally, in regard to the third condition, there is good evidence that OCD symptoms possess similar features in clinical and nonclinical samples. Intrusive thoughts tend to involve similar content as OCD obsessions (Radomsky et al., 2014; Julien, O'Connor, and Aardema, 2009), and often trigger covert rituals/compulsions such as mental checking, focused distraction, reassurance seeking, and thought replacement, which appear functionally equivalent to OCD compulsions (Freeston, Ladouceur, Provencher, & Blais, 1995; Berman, Abramowitz, Pardue, &Wheaton, 2010). Regarding symptom structure, OCD symptoms also tend to form similar factor-analytic dimensions across clinical and nonclinical college samples. For the OCI-R, Hajcak et al. (2004) replicated the same 6-factor structure in a college sample that was found by Foa et al. (2002) and Abramowitz and Deacon (2006) in clinical samples. Similar structural invariance across college and clinical samples has been demonstrated for other OCD assessment tools (e.g.,Watson & Wu, 2005; Sanavio, 1988). More recently, Abramowitz et al. (2010) found that OCD

symptoms conformed to the familiar 4-factor solution among a sample of healthy control participants, while the hierarchical bifactor model of Olatunji et al. (2017) was in a non-clinical group composed largely of college students.

Evidence for the empirical similarity across clinical and nonclinical college samples hasalso been demonstrated for other OCD-relevant domains. For one, obsessive beliefs (e.g., importance of controlling thoughts) form the same factor structure in both groups (OCCWG, 2005). Of note, the authors of this study also found that college-age participants scored significantly higher on all subscales of the OBQ-44 compared to a sample of community controls, building upon findings from Foa et al. (2002) in demonstrating that both OCD symptoms and beliefs elevated in college students. Experimental studies also support the notion that OCD patients and college participants are sensitive to the same symptom-producing mechanisms. For instance, the finding that OCD patients exhibit reduced memory confidence with repeated checking (e.g. Boschen & Vuksanovic, 2007) has been shown to occur similarly in samples of college students subjected to the same experimental manipulation (e.g., Dek, Van den Hout, Giele, & Engelhard, 2010; Van den Hout & Kindt, 2003).

In summary, the dimensional nature of OCD implies that results obtained using non- clinical samples can potentially be extrapolated to understand the illness in clinical contexts. Moreover, OCD symptoms in college students are more common compared to other non-clinical groups (e.g., community participants) and possesses many of the same features observed in

clinical samples (e.g., factor-analytic, structure, thematic content), making this population an especially apt analogue for understanding clinical OCD.

Conclusions

Although the current investigations would ideally test clinical samples assessed with a more comprehensive instrument (e.g., the Y-BOCS) and a more well-validated paradigm, it is clear that the OCI-R, the PIG paradigm, and college-age participants have a number of advantages when it comes to assessing links between OCD and SIC. Thus, these methods should help provide a strong initial test for the hypothesis that OCD symptoms will confer increased sensitivity to improbable, catastrophic threats.

Chapter 3: Experimental Evaluation of a Sensitivity to Improbable Catastrophes in OCD(Study 1)

The purpose of this first study was to perform an initial experimental test of whether OCD symptoms confer increased sensitivity to improbable catastrophes. Although this sensitivity is implied by the preponderance of OCD-relevant feared consequences involving improbable catastrophes, no studies to my knowledge have experimentally tested this observation by evaluating how persons with differing OCD symptoms respond to threats of varying probability and aversiveness. Additionally, the few past that found higher responding to improbable catastrophes in OCD utilized outcomes with known relevance to the disorder (e.g., hitting and killing a pedestrian: Aardema et al., 2008; contracting a life-threatening illness: Moritz & Jelinek et al., 2009), which only verifies the notion that consequences that elicit OCD symptoms in the real world may also do so in the laboratory. Thus, the use of a non-OCD- relevant threat in the current study (i.e., electric shock) should help clarify whether OCD actuallyinvolves a more generalized sensitivity to all scenarios bearing improbable, catastrophic features,regardless of the particular consequence such scenarios entail.

An additional purpose of this initial study was to test the relative contributions of probability-based and cost-based overestimations to the genesis of SIC. As reviewed in chapter1, phenomenological, empirical, and theoretical evidence suggests that the purported sensitivityto improbable catastrophes more likely arises from an overestimation of these events'

probabilities than from an overestimation of their costs. Phenomenologically, improbable consequences are more common in OCD than catastrophic ones, suggesting a sensitivity to improbable events is a more abiding feature of the illness. This proposition is further buttressed by empirical data showing that traits conferring overestimations in improbable threat likelihood are more consistently and specifically linked to OCD compared those implicated in cost-related overestimations. The primacy of probability-based distortions for SIC is also suggested by the nature of improbable catastrophes themselves, which could theoretically trigger fear and avoidance given only a small probability-based overestimation while requiring an excessive cost-related overestimation to yield the same result.

In the present study, I used an adapted version of the PIG paradigm (van Meurs et al., 2014) to test how participants with varying OCD symptoms would respond to threats with differing degrees of probability and aversiveness. Given the theory that OCD confers a specific sensitivity to improbable, catastrophic outcomes, I hypothesized that OCD symptoms would predict threat reactivity (expectancy ratings, subjective anxiety ratings, startle responses, avoidance choices) most strongly when the probability of the threat was low but subjective aversion to it was high. Additionally, I hypothesized that OCD symptoms would predict greater expectancy of improbable threat independent of levels of perceived aversiveness, consistent with overestimations of threat probability being a more central contributor to SIC. Overall, this first study should provide a strong initial test of whether OCD

involves a heightened sensitivity toward improbable catastrophes and whether this sensitivity results from a more general tendency to overestimate the likelihood of improbable threats.

Method

Participants

A total of 100 University of Minnesota students were recruited and tested. Inclusion criteria applied at screening included: 1) being at least 18 years old; 2) normal hearing and vision; 3) English speaking; 4) no current use of medications altering central nervous system function, including alcohol or illegal drugs up to 24 hours before the experiment; 5) no caffeineor nicotine intake for two hours prior to testing, and 6) not having participated in a previous conditioning experiment in our laboratory. All participants provided written informed consentafter receiving a complete description of the study.

Of the 100 tested participants, six were dropped due to validity concerns, as they provided invalid responses to validity items embedded in self-report questionnaires; five were excluded for failing to acquire the CS+/US contingency (as indicated by CS+ versus CS- probability rating difference scores less than or equal to zero); and 5 were missing task data necessary for the main analyses. Finally, 8 participants were excluded either because they were startle non-responders, or because of technical problems with EMG equipment resulted in their startle data not being collected. This left a final sample of N = 78 participants (68% female), witha mean age of 19.75 (*SD* = 1.44). Average Obsessive-Compulsive Inventory-Revised (OCI-R; Foa, et al.,

2002) total score was 19.42 (*SD* = 12.97). Furthermore, a large portion of OCI-R scores in the tested sample fell within the clinical range, with 41% of scores at or above the recommended clinical cut-off of 21 thought to indicate a likely presence of OCD, and 24% at or exceeding the mean among those diagnosed with OCD (OCI-R Total = 28) from previously published data (Foa et al., 2002).

Questionnaires

OCD symptoms were assessed using the Obsessive-Compulsive Inventory-Revised (Foa etal., 2002; see Chapter 2, Section 2.1for more details). Additionally, data on the Spielberger State and Trait Anxiety Inventory (STAI: Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was also collected to control for broad trait anxiety in testing effects with OCI-R.

Physiological Apparatus

Stimulation and recording were controlled by a commercial system (Contact Precision Instruments). Startle-blink EMG was recorded with two 6-mm tin cup electrodes filled with a standard electrolyte gel (SignaGel, www.biomedical.com[CG04]) placed under the right eye. More specifically, one EMG electrode was placed below the lower eyelid in line with the pupil in forward gaze, and the second electrode was placed approximately 2 cmlateral to the first. Additionally, a 9-mm disk electrode was placed on the anterior forearm and served as a ground. Impedance levels for EMG electrodes was maintained below 20 Kilohms. The EMG signal was sampled at 1000 Hz and amplifier band width was set to 30-

500 Hz. Startle was probed by a 50-ms duration, 102 dB(A) burst of white-noise with a near instantaneous rise-time presented binaurally through headphones.

Experimental Paradigm

An overview of the Pavlovian and Instrumental Generalization (PIG) paradigm can be found in chapter two. Here, I will only describe changes made in the adapted version of the PIG used in this particular study. First, self-reported risk ratings (i.e. "level of risk?"; 1 = "no risk", 2 = "some risk", 3 = "high risk") were replaced with separate ratings of subjective anxiety (anxiety ratings) and threat probability (threat expectancy ratings). This was done to ensure that participants' ratings of perceive threat probability were not conflated with their levels of perceived anxiety, as well as vice versa, as these outcomes served separate and equally importantpurposes in the current study. Anxiety ratings were elicited with the question, "Anxiety level?" (0 = "no anxiety", 10 = "extreme anxiety") and threat expectancy ratings with the question "Chance of shock?" (0 = 0% chance of shock, 10 = 100% chance of shock). These questions appeared for 3s on every Pavlovian trial at either 4s or 9s post-trial onset with a counterbalanced order such that each question appeared first on 50% of trials. To accommodate the increased timenecessary for answering these questions, shock during CS+ Pavlovian trials was not delivered until 16 s post-trial onset. To ensure that this gap did not result in insufficient levels of anxious

reactivity being experienced at beginning of trials when fear-potentiated startle

was measured, a‘dummy’ CS+ Pavlovian trial occurred once every 12 trials, during which no data was collected and shock was delivered at 4s post-trial onset.

Second, because varying levels of perceived threat aversion were necessary to test the questions in this investigation, this adapted version also varied the number of shocks accompanying CS+ during the Test phase, pairing it with one shock (low intensity), two shocks (moderate intensity), or three shocks (high intensity). Multiple shocks were delivered as separate,consecutive pulses spaced 1s apart, and shock across all conditions continued to occur on 50% of Pavlovian trials and 100% of instrumental trials when the short road was chosen. The number of shocks possible changed every 12 trials during the Test Phase, and the order of shock intensity blocks was counterbalanced so that for half of participants the number of shocks possible across the six blocks was: 1, 2, 3, 3, 2, 1, while for the other half it was reversed (i.e., 3, 2, 1, 1, 2, 3). The number of shocks participants were at risk for was shown in large font at the top of the screen for the duration of the block and each shock level had a distinct color (1 shock = blue, 2 shocks= orange, 3 shocks = red) to help ensure participant remained aware of the current shock condition. Threat aversion for each shock condition was measured as the level of motivation to avoid shocks (i.e., *“How important was it to avoid receiving shock?”*) and was assessed halfwaythrough Test phase and again at the end of the Test Phase.

Finally, to accommodate the increased time afforded by three (vs. one) shock conditions, two changes were made to keep the experiment a reasonable

length. First, acquisition involved only six presentations of each stimulus type (i.e., 2 ΔCS-, 2 CS-, 2 CS+), rather than eight in theoriginal version. Second, each shock condition during the Test phase only contained four presentations of each stimulus type (i.e., 4ΔCS-, 4 CS-, 4 GS_1, 4 GS_2, 4 GS_3, 4 CS+ for each shock level) rather than six as in the original version. All other aspects of the experiment wereconserved from the original version described in Chapter 2, Section 2.2.

Procedure

This study was approved by the University of Minnesota IRB. Following informedconsent, standardized questionnaires were filled out and EMG and shock electrodes were attached. Next, a shock-workup procedure was completed during which participants received several single shocks, the levels of which were adjusted so as to be rated as moderately or very painful but not extremely painful. Once the necessary level for a singleshock had been established, participants were then given three consecutive shocks (spaced1s apart as in the actual experiment) and asked whether they were still willing to receive three shocks at that level during the study. If participants said they were not willing to proceed, the level of shock was lowered until participants rated experience of three-shocks as at least moderately painful but still tolerable enough to complete the study.

Prior to the Acquisition phase, participants were told they might learn to predict shock by attending to the shapes in the center of the screen, but were not informed of the CS+/shock contingency. Next,

headphones were placed and a habituation sequence consisting of nine startle probes (IPI=18-25 s) was run while the background image of the two roads, the shed, and the garden was displayed. The Acquisition phase was followed by a10-min break during which time participants filled out a series of questionnaires regarding what they had learned in the experiment. Prior to the start of the Test phase, participants were given additional instructions concerning the avoidance portion of the task. Specifically, participants were told that what they learned during Acquisition about the relation between shapes and shocks still applied. Participants were also informed that they would now be able to choose the road traveled by the farmer on some trials, and the costs and benefits associated with each road were explained. Finally, participants were also told that the number of shocks they would be at risk for receiving would change throughout the next portion of the experiment, and that this number would always be indicated at the top of the screen. Participants then practiced using the button box to send the farmer down the longand short road. Next, five habituation startle probes were delivered (IPI=18-25 s) and the Test phase was run. Another 10-min break was provided halfway through the Test phase (i.e., after the first three 12-trial blocks), during which participants filled out another set of questionnaires, including separate questions for each level of shock asking participants to rate their threat aversion (i.e., “How important was it to not receive shock”) and desire to win the game (i.e., “How important was it to win the game”) on 10-point scales where 0

= “none” and 10 = “extreme”. Participants completed this same set of questions upon completion of the Test phase.

Data Analysis

Data processing. Startle EMG was rectified and then smoothed (20 ms moving window average). The onset latency window for the blink reflex was 20-100 ms and the peak magnitude was determined within a window of time extending from the response onsetto 120 ms. Additionally, the average baseline EMG level for the 50 ms immediately preceding delivery of the startle stimulus was subtracted from the peak magnitude. EMG magnitudes across all phases of the study were standardized together using within subject *T*-score conversions ($([([EMG_{single\ trial} - EMG_{mean}]/SD)*10]+50)$ to normalize data and reduce between participants’ variability unrelated to psychological processes. Threat expectancy ratings, anxiety ratings, and avoidance choices were linearly transformed to be on scales with values ranging from 0 and 100 and self-reported threat aversion and desire-to-win ratings were averaged for each level of shock (i.e., average of the two ratings collected midway and at the end of the Test Phase).

Data from the Test Phase were transformed to long format where each line represented a participant’s average level of responding (threat expectancy, anxiety ratings, fear-potentiated startle, avoidance choices) to a particular stimulus (ΔCS- , CS-, GS_1. GS_2, GS_3, CS+) within a specific shock-level condition (1, 2, or 3 shocks possible). Participants’ ratings of threat aversion

and desire-to-win were treated as 3-level variables wherein average ratings for each shock condition were used for all trials within that condition.

Manipulation checks. To verify that no differences in threat responses between stimuli existed prior to acquisition, each response type (threat expectancy, anxiety ratings, startle EMG) was separately averaged for each stimulus type during Preacquisition and analyzed with separate3-level (Stimulus type: ΔCS-, CS-, CS+) repeated measures analysis of variance (rANOVA). Similarly, to assess the acquisition of conditioned fear, separate 3-level (Stimulus type: ΔCS-, CS-, CS+) rANOVAs were assessed for each response type (threat expectancy, anxiety ratings,startle EMG) from the Acquisition Phase.

To test the effectiveness of the probability manipulation during the Test phase, a one-way rANOVA tested whether threat expectancy ratings differed as a function of stimulus type. Further, paired-samples *t*-tests were conducted to verify that the three stimuliwith the least resemblance to CS+ (ΔCS-, CS-, GS_1; hereafter referred to as the *improbable threat cluster*) were a) rated as less likely to result in shock compared to the stimuli that most resembled CS+ (i.e., GS_2, GS_3, CS+; hereafter referred to as the *more probable threat cluster*) and b) not rated as significantly different from each other. Similarly, to test whether the manipulation of threat intensity (i.e., number of shocks) elicited additional within- subject variability in shock aversion, an additional 3-level (1-shock, 2-shock, 3-shock) one-way rANOVA (along with paired-samples t-tests) was

conducted to verify that threat aversion ratings increased as a function of shock intensity.

Main analyses. For the main analyses, separate linear mixed effects models (LMMs) were built to predict each response collected during the Test phase: threat expectancy ratings, anxiety ratings, fear-potentiated startle responses, and avoidance choices. LMMs offer several advantages for assessing individual differences in responding within generalization paradigms, including the treatment of stimuli as a continuous dimension, allowing for dependency among predictors, and relaxing assumptions regarding the presence of equivalent variance between stimuli (Vanbrabant et al., 2015). Predictors in each LMM included: 1) the participant-specific intercept (random effect); 2) the main effects of stimulus type, threat aversion ratings, and total OCI-R score, 3) each of the three two-way interactions between these variables; and 4) the three-way interaction. All models were fit with maximum likelihood procedures, with chi square goodness-of-fit statistics comparing models with: a) just random effects, to b) models with random effects and main effects, to c) models with main effects and each two-way interaction, to d) those with main effects, two-way interactions, and the three-way interaction.

To limit the number of significance tests, higher order models for each dependent variable were not tested if the preceding lower order model failed to provide a significance increase in model fit. I also provide

the *t*, *p* and Cohen's *d* values as a measure of effect size($d = t(2/n)^{1/2}$; Dunlop, Cortina, Vaslow, & Burke, 1996) for individual predictors within themodel they were the highest order term. Degrees of freedom for the *t*-values of individual predictors were calculated using Satterthwaite's formula (Satterthwaite, 1941)—a common correction applied to *t*-tests of individual predictors in LMMs.

Interactive effects of OC symptoms, stimulus type, and threat aversion. Of central importance to this study was whether the 2- and 3-way interactions involving OCD symptoms within LMMs predicted greater threat responding. Two-way interactions including OCI-R (OCI-R x Stimulus type, OCI-R x Threat-aversion) tested the extent to which the relations between OCI-R and threat responding depended *independently* on the probability and aversiveness of potential threats, while the 3-way interaction (Stimulus typex Threat-aversion x OCI-R) tested the primary hypothesis that links between OCI-R and threat responding would depend synergistically on the threat probability *and* aversion. It was predicted that these 3-way interactions would be in the negative direction, such that higher OCD symptoms would better predict greater threat responding when stimuli less resembled danger and threat aversion ratings were higher.

Significant two-way interactions involving stimulus type were followed up with simple slopes (beta weights plus 95% confidence intervals) of the effect of OCI-R on threat responding at each level of

stimulus type. Significant interactions involving threat aversion were followed up with simple slopes of the effect of OCI-R at low (-1*SD* below the mean) and high (+1*SD* above the mean) levels of threat aversion. Significant 3-way interactions were followed up with tests of whether two-way threat aversion x OCI-R interactions predicted greater responding toward stimuli within the improbable and more probable threatclusters separately, along with simple slopes of these interactions. It was predicted that there would be significant, positive interaction between OCI-R and threat aversion ratings within the improbable threat cluster *only*, such that higher OCI-R scores would predict greater threat responding specifically when threats were improbable and perceived as moreaversive.

Testing the specificity of OC symptoms and aversive motivation. To ensure significant effects with OCD symptoms were not driven by a more anxious dispositions in general, significant effects were re-analyzed using standardized residuals extracted from a model in which STAI-T (trait anxiety) was used to predict OCI-R. Since these residuals reflect levels of OCI-R after portioning out variance that is shared with STAI-T, they may be used to test the unique contribution of OCI-R in tested models beyond the effect of broad trait anxiety.

Also, to test whether results were specific to aversive motivation, significant modelsinvolving threat aversion ratings were re-run replacing these ratings with desire-to-win ratings, which have been used to test the effects of appetitive motivation on PIG task performance in previous

investigations (Hunt et al., 2019).

Exploratory analyses. Finally, to examine which specific kind of OCD symptoms contributed to significant effects, I reran the same analytic plan above replacing OCI-R scores with each symptom subscale: Washing, Checking, Ordering, Obsessing, Hoarding, and Neutralizing. Since no explicit hypotheses were made regarding which subscales would demonstrate the predicted effects most strongly, analyses at the subscale level are considered exploratory. Alpha was set at 0.05 (two-tailed) for all statistical tests.

Results

Preacquisition

Prior to conditioning, no differences across stimuli (ΔCS- , CS-, CS+) were detected interms of threat expectancy ratings ($p = .12$), anxiety ratings ($p = .69$), or startle ($p = .64$).

Acquisition

During Acquisition, main effects of stimulus type were found for threat expectancy, $F(3, 74) = 159.95$, $p < .001$, $\eta^{\$} = .68$, anxiety ratings, $F(3, 74) = 24.59$, $p < .001$, $\eta^{\$} = .24$, and startle, $F(3, 74) = 3.16$, $p = .045$, $\eta^{\$} = .04$. Individual comparisons for threat expectancy ratings indicated that participants rated the CS+ ($M = 69.99$, $SD = 19.55$) as significantly more likely to result in shock relative to both the CS- ($M = 28.72$, $SD = 22.42$; $p < .001$) and the ΔCS- ($M = 27.24$, $SD = 19.26$; $p < .001$), which did not differ from each other ($p = .48$). Similarly, participants reported significantly more anxiety in the presence

of the CS+ (M = 48.37, SD = 21.72) compared to both the CS- (M = 36.70, SD = 22.39; $p < .001$) and the ΔCS- (M = 36.60, SD = 22.48; $p < .001$), which were again not significantly different from each other ($p = .95$). Participants also had significantly greater startle to the CS+ (M = 51.48, SD = 5.40) relative to the ΔCS- (M = 50.03, SD = 5.53; $p = .023$) but not the CS- (M = 51.13, SD = 5.53; $p = .57$). Startle to CS- was also higher than ΔCS- at the level of a trend (p = .06).

Test Phase

Manipulation checks

Threat probability. Threat expectancy ratings were found to differ significantly as a function of stimulus type, $F(5, 72) = 294.92$, $p < .001$, $\eta^2 = .79$, which was driven by a continuous decline in threat appraisal (see Figure 3.1.A below) as stimuli became more dissimilar from CS+ (linear decrease: $F(1, 76) = 458.51$, $p < .001$, $\eta^2 = .86$; quadratic decrease: $F(1, 76) = 260.66$, $p < .001$, $\eta^2 = .77$). Thus, threat was perceived as more improbable as stimuli became more dissimilar from the danger cue. Consistent with previous investigations, pairwise comparisons revealed that all stimuli from the improbable threat cluster (ΔCS- , CS-, GS_1) were a) appraised as significantly less likely to result in shock compared to stimuli from the more probable threat cluster (GS_2, GS_3, CS+; all ps < .001) and b) not appraised as more or less likely to result in shock compared to each other (ps > .26). Thus, results supported the pre-

planned dichotomization of stimuli into improbable and more probable threat clusters.

Threat aversion. A significant effect of shock condition was also found for shock aversion ratings, $F(3, 74) = 46.52$, $p < .001$, $\eta^2 = .38$., wherein participants reported greater aversion to threat as the number of shocks increased (see Figure 3.1.B below). Pairwise comparisons revealed that aversion was greater during the 3-shock condition relative to the 2-shock and 1-shock conditions (*p*s < .001);, while threat aversion during the 2-shock conditionwas greater relative to the 1-shock condition ($p = .001$). As such, the threat intensity manipulation produced the within-subject variability in perceived threat aversion necessary to conduct the main analyses.

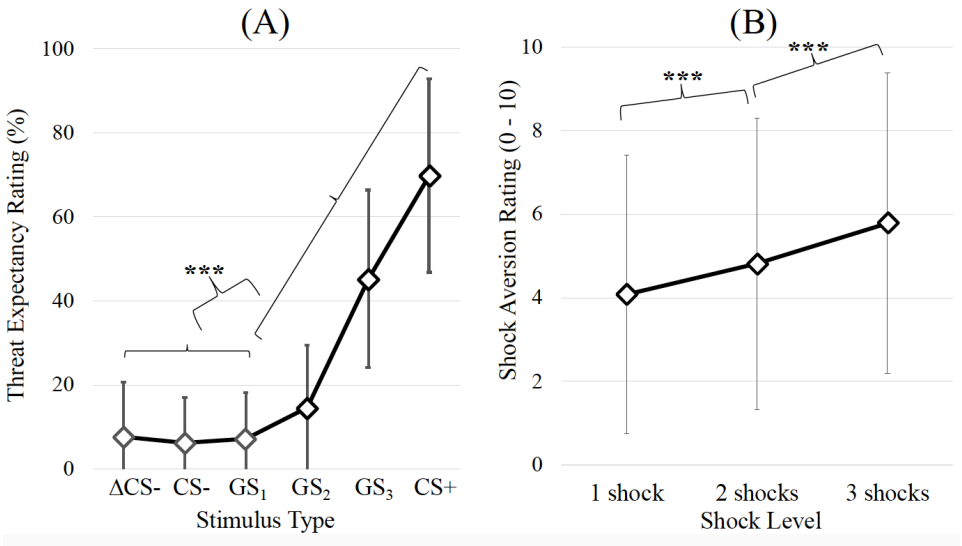


Figure 3.1. Differences between stimuli in terms of threat expectancy ratings (A) and shock intensity levels in terms of shock aversion ratings (B). The three stimuli least resembling CS+ (ΔCS-, CS-, GS_1) were all rated as significantly less likely to result in shock compared to the three stimuli most resembling CS+ (GS_2, GS_3, CS+) and were also not rated significantly differently from each other (ps > .26). ΔCS- = triangular safety cue; CS- =

circular safety cue'GS_{1-3}= generalization stimuli. CS+ = conditioned danger cue. ***p ≤ .001. N = 78.

Interactive effects of threat aversion, stimulus type, and OCI-R.

Model statistics for each threat response variable can be found below in Table 3.1 below. Throughout all tests, adding the main effects of OCI-R, stimulus type, and threat aversion increased model fit relative to models with just random effects (*p*s < .001), which was clarified by a significant positive effect for stimulus type for all outcomes (*p*s < .001). There was also a significant effect of threat aversion for all outcomes (*p*s < .001) besides EMG (threat aversion: *p* = .34). In contrast, the main effect of OCI-R was not a significant predictor for any threat-response outcome (*p*s > .20). Table 3.1. Linear mixed model statistics for each threat response outcome.

Table 3.1: Linear Mixed Effects Models for Each Threat Response Outcome

Dependent Variable	Model	Predictor	χ^2	*t*	*d*	*p*
Avoidance Choices	Main		610.47			< .001
		Stimulus Type		25.38	4.06	< .001
		Aversion Ratings		11.09	1.77	< .001
		OCI-R		1.29	0.21	.20
	2-way		339.19			< .001
		Stimulus x Aversion		19.62	3.14	< .001
		Stimulus x OCI-R		-2.64	0.42	.0083
		Aversion x OCI-R		0.47	0.075	.64
	3-way	Stimulus x Aversion x OCI-R	21.88	-4.70	0.75	< .001
Threat Expectancy Ratings	Main		1139.99			< .001
		Stimulus Type		42.04	6.72	< .001
		Aversion Ratings		4.44	0.71	< .001
		OCI-R		0.13	0.020	.90
	2-way		15.73			.0012
		Stimulus x Aversion		2.79	0.44	.0054
		Stimulus x OCI-R		-3.20	0.51	.0014
		Aversion x OCI-R		0.77	0.12	.44
	3-way	Stimulus x Aversion x OCI-R	0.091	0.30	0.048	.77
Startle EMG	Main		183.55			< .001
		Stimulus Type		13.97	2.24	< .001
		Aversion Ratings		0.96	0.15	.34
		OCI-R		NA		NA
	2-way		7.19			.066
		Stimulus x Aversion		0.88	0.14	.38
		Stimulus x OCI-R		-2.22	0.36	.029
		Aversion x OCI-R		1.45	0.23	.15

	3-way	Stimulus x Aversion x OCI-R	0.032	-0.18	0.029	.85
Anxiety Ratings	Main		715.82			< .001
		Stimulus Type		29.61	4.74	< .001
		Aversion Ratings		7.33	1.17	< .001
		OCI-R		1.05	0.17	.30
	2-way		91.18			< .001
		Stimulus x Aversion		9.55	1.53	< .001
		Stimulus x OCI-R		-0.46	0.074	.65
		Aversion x OCI-R		-1.17	0.19	.24
	3-way	Stimulus x Aversion x OCI-R	1.54	-1.24	0.20	.22

OCI-R = Obsessive Compulsive Inventory Revised. N = 78.

Threat expectancy ratings. Adding the constituent two-way interactions between OCI-R,threat aversion, and stimulus type led to an incremental increase in model fit for threat expectancy ratings, which was further clarified by a significant, OCI-R x Stimulus type interaction, $t(1324) = -3.20$, $p = .0014$, $d = 0.51$. Simple slopes of the effect of OCI-R on threat expectancy ratings for each level of stimulus type revealed that higher OCI-R scores were associated with increasingly heightened ratings of threat probability as threat became less probable, with effects becoming less negative from CS+ (β = -.072, 95% CI [-.16, 0.018], $t(76) = -1.62$, $p = .11$) to GS_3 (β = -.041, 95% CI [-.12, 0.041], $t(76) = -1.62$, $p = .32$) to GS_2 (β = -0.009, 95% CI [-.0.085, 0.065], $t(76) = -0.23$, $p = .82$) and increasing in positive strength from GS_1 (β =0.023, 95% CI [-.052, 0.098], $t(76) = 0.63$, $p = .53$) to CS- (β = 0.055, 95% CI [-.025, 0.14], $t(76) = -1.62$, $p = .17$) to ΔCS- (β = 0.087, 95% CI [-0.03, 0.18], $t(76) = 1.95$, $p = .055$). Fitted threat expectancy values for high (+1 *SD* above the mean) and low (- 1 *SD* below the mean) OCI-R at each level of stimulus type can be found in Figure 3.2.A. In contrast, inclusion of thethree-way Threat aversion x OCI-R x Stimulus type failed to produce a further incremental increase in model fit, $\chi^2(1) = 0.091$, $p = .76$.

Anxiety Ratings. For subjective ratings of anxiety, including the two-way interactions between OCI-R, threat aversion ratings, and stimulus type led to an incremental increase in model fit, χ^2 (3) = 94.18 , $p < .001$. However, the OCI-R x Stimulus type interaction failed to reach significance ($p = .65$), and inclusion of the three-way Threat aversion x OCI-R x Stimulus type interaction failed to produce a further incremental increase in model fit, χ^2 (1) = 1.55 , $p = .21$.

Startle EMG. For startle, including the two-way interactions between OCI-R, Threat Aversion, and Stimulus Type led to an incremental increase in model fit at the level of a trend, χ^2 (3) = 7.72 , $p = .066$. Within the two-way interaction model, there was once again a significant, negative OCI-R x stimulus type interaction, $t(1324) = -2.20$, $p = .028$, $d = 0.36$, which simple slopes revealed was again driven by OCI-R scores becoming increasingly predictive of startle asthreats became less probable, with the effects becoming less negative from CS+ (β = -.053, 95%CI [-.15, 0.053], $t(76) = -1.02$, $p = .32$) to GS_3 (β = -0.021, 95% CI [-.11, 0.065], $t(76) = -0.49$, $p = .63$), and increasing in positive strength from GS_2 (β = 0.01, 95% CI [-.0.075, 0.077], $t(76) = 0.27$, $p = .79$) to GS_1 (β = 0.042, 95% CI [-.034, 0.12], $t(76) = 1.10$, $p = .28$) to CS- (β = 0.074, 95% CI [-.012, 0.16], $t(76) = 1.70$, $p = .093$) to ΔCS- (β = 0.11, 95% CI [0.01, 0.21], $t(76) = 2.02$, $p = .046$). The fitted startle value for high (+1 *SD* above the mean) and low (- 1 *SD* below the mean) OCI-R at each level of stimulus type can be found in Figure 3.2.B. In contrast, inclusion of the three-

way threat aversion x OCI-R x Stimulus type interaction again failed to produce a further incremental increase in model fit for startle data, $^2(1) = 0.032$, $p = .86$.

Avoidance choices. Including the two-way interactions between OCI-R, Threat aversion, and Stimulus type also led to an incremental increase for avoidance, $^2(3) = 339.19$, $p = .0012$,which was clarified by a significant OCI-R x Stimulus type interaction, $t(1324) = -2.89$, $p = .004$,$d = 0.42$. Simple slopes for this effect again revealed that higher OCI-R scores again predicted increasingly heightened avoidance as threats became less probable, with effects increasing from CS+ (β = -.0045, 95% CI [-.10, 0.95], $t(76) = -0.89$, $p = .93$) to GS_3 (β = 0.021, 95% CI [-0.071, 0.11], $t(76) = 0.45$, $p = .65$) to GS_2 (β = 0.046, 95% CI [-.0.042, 0.13], $t(76) = 1.045$, $p = .30$) to GS_1 (β = 0.072, 95% CI [-0.016, 0.16], $t(76) = 1.62$, $p = .11$) to CS- (β = 0.097, 95% CI [0.05, 0.19], $t(76) = 2.09$, $p = .04$) to ΔCS- (β = 0.13, 95% CI [0.03, 0.23], $t(76) = 2.44$, $p = .017$). The fitted avoidance value for high (+1 *SD* above the mean) and low (- 1 *SD* below the mean) OCI-R at each level of stimulus type can be found in Figure 3.2C

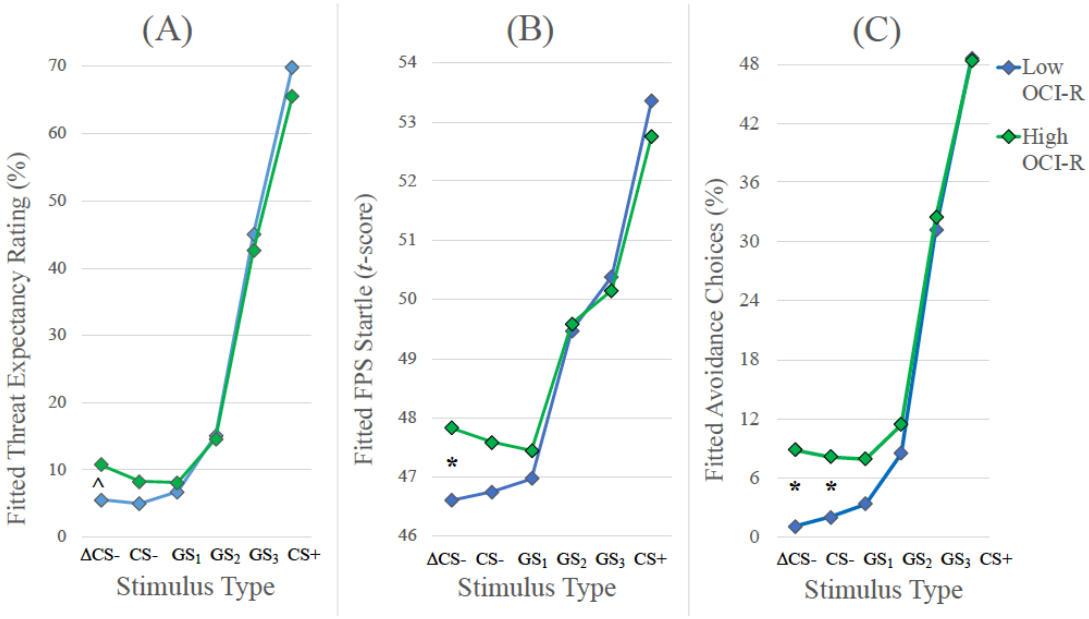


Figure 3.2. Differences in (A) threat expectancy ratings, (B) startle, and (C) avoidance choices across low (- 1*SD* below the mean; blue line) and high (+1*SD* above the mean; green line) levels of OCI-R as a function of stimulus type. Levels of each response are expressed as fitted values estimated from simple slopes of the effect of OCI-R at each level of stimulus type. OCI-R = Obsessive Compulsive Inventory Revised; ΔCS- = triangular safety cue; CS = circular safety cue; GS = Generalization Stimulus CS+ = conditioned danger cue. *$p \leq .05$. ^$p \leq .056$. N = 78.

Additionally, including the three-way Threat-aversion x OCI-R x Stimulus type interaction led to a further incremental increase in model fit for avoidance, $^2(1) = 21.88$, $p < .001$, which was in the negative direction as predicted, $t(1324) = -4.70$, $p < .001$, $d = 0.75$. Further, examining the Threat-aversion x OCI-R effect separately within clusters of improbable threat (ΔCS-, CS-, GS_1) and more probable threat (GS_2, GS_3, CS+) revealed that this interaction significantly predicted avoidance of stimuli from the improbable threat cluster, $t(622) = 2.78$, $p = .006$, $d = 0.44$, but not the more

probable threat cluster, $t(622) = -0.36$, $p = .72$. Simple slope analyses (see Figure 3.3 below) revealed positive relations between levels of threat aversion and avoidance during improbable threat stimuli at high ($\beta = 0.19$, 95% CI [0.12, 0.26], $t(622) = 5.35$, $p < .001$) but not low levels of OCI-R, $\beta = 0.03$, 95% CI [-0.01, 0.08], $t(622) = 0.75$, $p = .45$, and positive relations between threat aversion and avoidance during more probable threat at both high levels of OCI-R ($\beta = 0.67$, 95% CI [0.54, 0.80], $t(622) = 10.16$, $p < .001$) and low levels OCI-R ($\beta = 0.70$, 95% CI [0.57, 0.83], $t(622) = 10.94$, $p < .001$). Thus, OCD symptoms predicted the greatest avoidance on trials where threats were both highly improbable and perceived as maximally aversive.

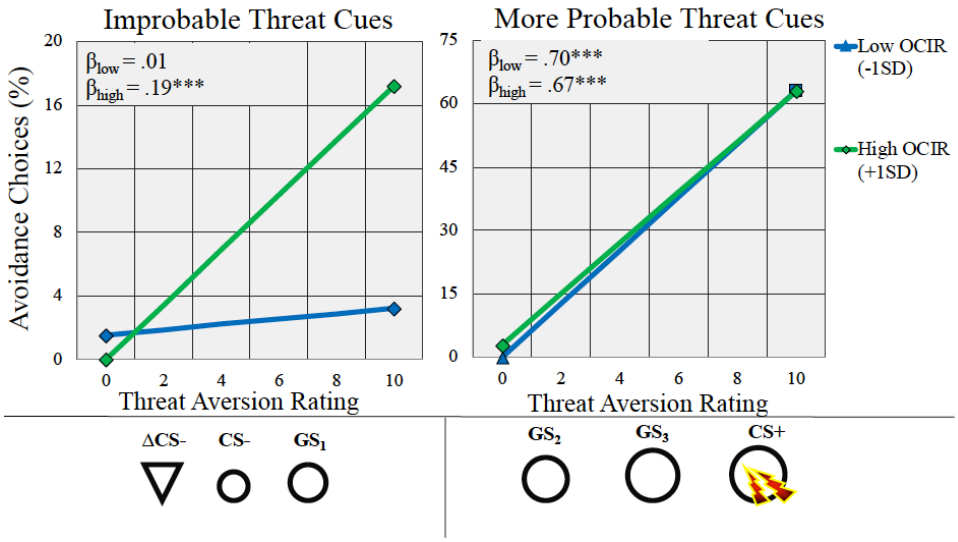


Figure 3.3. Relations between self-reported threat aversion (x-axis) and the percentage of avoidance choices committed (y-axis) in the presence of improbable (left) and more probable (right) threat cues. Different color lines represent the relationship between these variables at - 1*SD* below mean for OCI-R (blue lines) and +1*SD* above the mean for OCI-R (green lines). Cuesthat compose improbable and more probable stimulus clusters are shown below graphs (danger cue on far right). OCI-R = Obsessive Compulsive Inventory

Revised; ΔCS- = triangular safety cue; CS- = circular safety cue' GS_{1-3} = generalization stimuli. CS+ = conditioned danger cue. N =78.

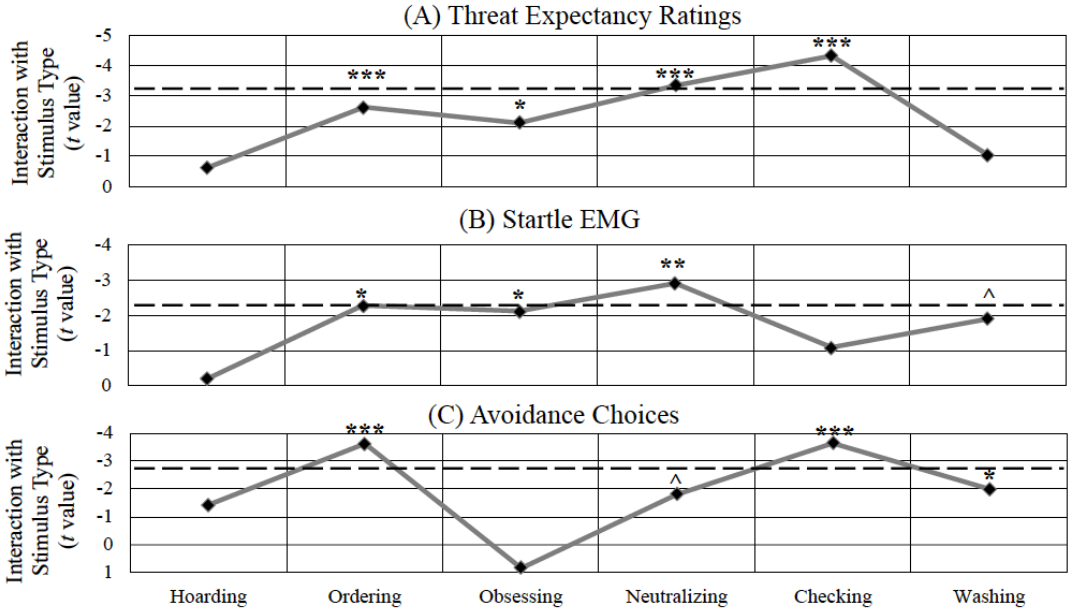
Specificity of effects to OCD symptoms. Re-testing significant effects portioning out variance in the OCI-R that was shared with STAI-T (trait anxiety) revealed that the OCI-R x Stimulus-type interaction remained a significant, negative predictor of threat expectancy ratings,$t(1324) = -3.00$, $p = .0027$, $d = 0.48$, startle, $t(1324) = -2.43$, $p = .015$, $d = 0.39$, and avoidance choices, $t(1324) = -2.94$, $p = .033$, $d = 0.47$. Similarly, the negative, 3-way OCI-R x Threat- aversion x Stimulus-type interaction also remained significant, $t(1324) = -5.19$, $p < .001$, $d = 0.83$. Thus, OCI-R effects appeared attributable to OCD symptoms as opposed to general levels of dispositional anxiety.

The contribution of appetitive motivational processes on relations between OCI-R and avoidance. Unlike results with threat aversion ratings, the three-way interaction between stimulus type, OCI-R scores, and self-reported desire to win failed to result in incrementally more likely model of avoidance choices, $^{2}(1) = 0.74$, $p = .39$. Thus, OCD symptoms appeared to interact specifically with aversive motivation in facilitating greater avoidance of more improbable threats.

Exploratory analyses with OCI-R subscales. Finally, to explore whether significant results were driven by specific OCD symptoms, I re-tested the significant OCI-R effects for threat expectancy, startle EMG, and avoidance choices replacing overall OCI-R with scores on each OCI-R subscale. The strength of two-way interaction (*t*-values) involving stimulus

type foreach OCI-R subscale relative to overall OCI-R scores can be found in Figures 3.4.A (threat expectancy ratings), 3.4.B (Startle EMG), and 3.4.C (Avoidance) below.

Figure 3.4. Strength of interaction (y-axis) between each OCI-R subscale (x-axis) with stimulus type in prediction of A) threat expectancy (top), B) startle (middle), and C) avoidance choices (bottom) compared to the same effect with overall OCI-R (black dashed line). All y-axes are expressed in reverse order with higher negative values expressed on top. Increasingly negative *t* values indicate a more gradual



decline in anxiety-related responding as stimuli communicated moreunrealistic threat. OCI-R = Obsessive Compulsive Inventory Revised. ^$p \leq .07$; *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$. N = 78.

Threat expectancy ratings. Including the two-way interactions between threat aversion, stimulus type, and OCI-R subscale scores led to an incremental increase in model fit for models across all subscales (*p*s < .001). Further, there was a negative, two-way interaction with Stimulustype for the Checking, $t(1324) = -4.43$, $p < .001$, Neutralizing, $t(1324) = -3.36$, $p = .0008$, Obsessing $t(1324) = -2.11$, $p = .035$), and Ordering subscales, $t(1324) = -2.63$, p = .0088,

but not for the Washing, $t(1324) = -1.05$, $p = .28$, or Hoarding subscales, $t(1324) = -.63$, $p = .53$.

Like overall OCI-R, no 3-way interaction was observed between Stimulus type, Threat aversion, and any OCI-R subscale ($ps > .05$).

Startle EMG. Including the two-way interactions with Threat aversion and Stimulus type led to an incremental increase in model fit for the Neutralizing subscale, $^{2}(3) = 0.74$, $p = .39$, but not any other subscale ($ps > .08$). However, there were negative, two-way interaction with Stimulus Type for the Obsessing, $t(1324) = -2.11$, $p = .035$, Neutralizing, $t(1324) = -2.91$, $p = .0037$, and Ordering, $t(1324) = -2.27$, $p = .024$ subscales, as well as for the Washing subscale atthe level of a trend, $t(1324) = -1.91$, $p = .057$.

No 3-way interaction between stimulus type, threat aversion, and any OCI-R subscalewas predictive of startle ($ps > .25$).

Avoidance Choices. Including the two-way interactions with Threat aversion and Stimulus type led to an incremental increase in model fit across all OCI-R subscales in predictingavoidance ($ps < .001$). This interaction was clarified by significant negative, two-way interactionwith Stimulus Type for the Checking, $t(1324) = -3.64$, $p = .0003$, Washing, $t(1324) = -2.00$, $p = .044$, and Ordering subscales, $t(1324) = -3.61$, $p = .00031$, and the Neutralizing subscale at the level of a trend, $t(1324) = -1.80$, $p = .074$.

Across all subscales, the 3-way interaction with Stimulus type and Threat aversion ratings emerged as a significant, negative predictor of avoidance choices ($ps < .020$). However, the Hoarding, Obsessing,

Neutralizing, and Ordering subscales all failed to demonstrate a significant interaction with threat aversion ratings in predicting avoidance of stimuli within eitherthreat cluster (*p*s > .17). In contrast, avoidance of stimuli within the improbable threat cluster was strongly predicted by two-way interactions between Threat aversion ratings and the Washing, $t(622) = 5.50$, $p < .001$ $d = 0.88$, and Checking subscales, $t(622) = 4.29$, $p < .001$, $d = 0.69$, neither of which interacted with Threat aversion to predict avoidance of stimuli from the more probable threat cluster (*p*s > .41).

Simple slopes revealed that higher Threat aversion ratings predicted greater avoidance of stimuli in the improbable threat cluster at high levels of Washing, β = 0.23, 95% CI [0.16, 0.29], $t(622) = 6.80$, $p < .001$, but not low levels of Washing, β = -0.03, 95% CI [-0.10, 0.04], $t(622) = -0.73$, $p = .47$, while avoidance in the more probable threat cluster was predicted by higher Threataversion at both high, β = 0.73, 95% CI [0.59, 0.87], $t(622) = 10.26$, $p < .001$, and low levels of Washing, β = 0.65, 95% CI [0.52, 0.77], $t(622) = 10.46$, $p < .001$. Similarly, higher Threat aversion ratings predicted greater avoidance of stimuli within the improbable threat cluster at high levels of Checking, β = 0.20, 95% CI [0.26, 0.14], $t(622) = 6.19$, $p < .001$, but not low levels of checking, β = -.019, 95% CI [-0.099, 0.061], $t(622) = 0.27$, $p = .78$, while avoidance of more probable threat stimuli was predicted by greater Threat aversion ratings at both high, β = 0.65, 95% CI [0.52, 0.78], $t(622) = 9.87$, $p < .001$, and low levels of Checking, β = 0.73, 95% CI [0.60, 0.86], $t(622) = 11.23$, $p < .001$.

Discussion

The current study offers the first lab-based test of whether OCD symptoms are associatedwith a general sensitivity to *improbable catastrophes*—a type of negative consequence commonly feared across a diverse array of OCD subtypes. The proposed link between OCD and improbable catastrophes was tested by examining whether OCD symptoms predicted greater threat responding (threat expectancy, anxiety ratings, startle responses, avoidance choices) to cues signaling parametrically varying levels of threat probability and threat aversion. Results show that, among those with greater OCD symptoms, higher levels of threat aversion were associated with greater avoidance of threats judged as very unlikely to result in shock, such that the relationship between avoidance and OCD symptoms was strongest when threats were both improbable and highly aversive. Additionally, higher OCD symptoms predicted greater threat expectancy, startle, and avoidance as potential threats became more improbable but not as they became more aversive. Thus, those with greater OCD symptoms exhibited a heightened sensitivity toward improbable threats, but not more aversive threats, that was reflected in their cognitive appraisals, physiology, and behavior. Importantly, the use of an OCD-unrelated threat in this experiment (i.e., electric shock) suggests that relations between OCD symptoms and threat responding are attributable to more generalizable features of threat probability and aversiveness rather than any specific source of threat.

Combined Effects of Threat probability and Aversion

That avoidance of improbable threats increased with levels of perceived threat aversion for individuals with higher OCD symptoms offers initial experimental validation for the notion that those with OCD are sensitive to improbable, catastrophic threats. Specifically, differences inavoidance between those high and low on OCD symptoms were greatest during the lab-based analogue of this very situation: Trials in which the individual was very averse to the consequences of shock but was presented with a stimulus judged as very unlikely to result in shock. In contrast, when facing more probable threats, levels of perceived threat aversion had an equivalent influence on avoidance for those with high and low levels of OCD symptoms. Thus, OCD symptoms did not appear to confer a tendency to avoid all types of threat, but rather a specific proclivity to avoid threats that were both very unlikely and highly aversive.

Unexpectedly, passive forms of threat reactivity—startle and subjective anxiety—were not predicted by the hypothesized three-way interactions involving threat probability, threat aversion, and OCD symptoms. Thus, while those with higher OCD symptoms were more likely to avoid improbable, highly aversive threats, they did not exhibit elevated levels of startle and subjective anxiety in their presence. Though perplexing, these null findings could be attributed to two possible reasons. First, avoidance of improbable catastrophes among those greater in OCD symptoms may have represented a *better-safe-than-sorry* strategy—a precautionary attempt to mitigate the potential that a harmful, improbable event would occur rather than a reaction to

an anxious state. While potential danger tends to prompt better safe than sorry strategies in all people due to its evolutionary advantage (Smeets et al., 2000; Stich, 1990), those with OCD arethought to be over-reliant on such strategies (De Jong & Vroling, 2014; Gangemi, Mancini & Dar, 2015). For example, an individual with checking OCD who has only minimal doubt that their stove is turned off after repeatedly checking may continue to check because of an overly strong need to be safe rather than sorry. According to this line of thinking, those high on OCD symptoms displayed heightened responding to low probability, highly aversive threats with active but not passive measures of threat reactivity because only the former measure was influenced by biases toward a better safe than sorry policy.

A related explanation for the differential results across active and passive measures of threat responding stems from the well-established link between OCD and inflated responsibility (Salkovskis et al., 2000; Myers et al., 2008): The house burned down because the individual forgot to turn off the stove, contracted HIV because they failed to wash their hands properly or killed some loved one because they failed to lock away dangerous objects when they had the chance. Accordingly, it could be that those with OCD are particularly sensitive to consequencesthat are improbable, catastrophic, and (theoretically) preventable. This possibility may account for the particular pattern of findings in this study because OCD-related abnormalities in active but not passive threat responses are subject to inflation by excessive needs to avoid carelessness.While better-safe-than-sorry biases and heightened

concerns with carelessness are plausible sources of heightened avoidance of low probability, high aversion threats in OCD, they remain unverified, and future OCD work is needed to explicitly assess the influence of such constructson levels of reactivity to experimental analogues of improbable catastrophes

Independent Effects of Threat probability and Aversion

That OCD symptoms were associated with higher threat responding (threat expectancy, startle, avoidance) as threats became more improbable, but not more aversive, is consistent with improbable catastrophes arising in OCD through a broad tendency to overestimate the likelihoodof improbable threats as opposed to the costs of more aversive ones. Specifically, those with higher OCD symptoms exhibited increased startle, threat expectancy, and avoidance relative to those with lower OCD symptoms as threats became more improbable, independent of how averse they were to the threat's consequences. This result echoes findings from several past experimental studies showing that OCD participants continue to exhibit heightened uncertainty, checking, or indecisiveness when confronted with low-probability events bearing low or absent costs (Fear & Healy, 1997; Foa et al., 2001; Pélissier et al., 2002; Hermans et al., 2008). Moreover, while those with OCD have been shown to invariably overestimate the likelihood of experiencing an improbable, OCD-relevant catastrophe, their perception of such events' aversiveness is mixed (e.g., Niemeyer et al., 2013 vs. Moritz & Jelinek, 2009). Thus, results from this study and past studies suggest that OCD involves a heightened sensitivity to

improbable events independent of their costs, but not catastrophic events independent of their probabilities.

While OCD predicted increased expectancy to improbable threat, the elevation was quiteslight: Those with OCD symptoms 1 *SD* above the mean found improbable threats only 5% morelikely than those with OCD symptoms 1 *SD* below the mean. This finding coheres with results by Moritz and colleagues (e.g., Moritz & Jelinek, 2009), where OCD patients typically rated their personal vulnerability for improbable catastrophes within 1 point of healthy controls on a 7-point scale of likelihood, and never exceeded the midpoint of four. Additionally, these marginal increases in perception of improbable threat are consistent with the fact that most OCD patients possess intact insight into the senselessness of their symptoms (e.g., Marazzti et al., 2002; Kishore, Samar, Reddy, Chandrasekhar, & Thennarasu, 2004) and do not typically appraise their feared consequences as very likely (Foa and Kozak, 1995; Tolin et al., 2001).

Interestingly, results with startle were virtually identical to those with perceived threat likelihood: OCD symptoms were increasingly predictive of startle magnitudes as threat cues became more improbable. Thus, the increased proclivity to overestimate improbable threat proposed as central to SIC may have also been encoded on a physiological level. Support for thisidea comes from several studies linking OCD symptoms to increased physiological arousal during safety. For instance, Borelli et al. (2015) found that children higher on OCD symptoms exhibited increased startle to learned safety cues but not

learned threat cues, while Lazarov and colleagues have consistently found that individuals with greater OCD symptoms display more spontaneous spikes in galvanic skin responses during a relaxation task (Lazarov, Dar, Oded, & Liberman, 2010; Lazarov, Dar, Liberman, & Oded, 2012). Consistent with these studies, the current findings suggest that those with greater OCD symptoms may be less able to taper down their threat-related arousal even toward stimuli that are clearly distinguishable from danger.

Interpreting Effects of Specific OCD Symptom Presentations

Although no specific hypotheses were made about which OCD symptoms would influence responding to improbable and aversive threats, two intriguing patterns emerged across analyses with individual OCI-R subscales. First, it is noteworthy that Washing and Checking were the only two OCI-R subscales that interacted with threat aversion to predict heightened avoidance of improbable threats. An interesting feature of these subscales is that their items largely pertain to *behavioral* responses that are often used by OCD patients as a form of avoidance (e.g., "I repeatedly check gas and water taps and light switches after turning them off", "I wash my hands more often and longer than necessary"). Thus, these subscales may have thus been particularly germane predictors for the behavioral avoidance of improbable aversive threats assessed in the PIG paradigm, while other subscales like Neutralizing that pertain to more*mental* avoidance responses (e.g., "I feel I have to repeat certain numbers") may not been a particularly good match to the behavioral avoidance measured by the PIG paradigm.

Second, Hoarding emerged as the only subscale failing to predict heightened respondingto improbable threat across any index of threat responding (i.e., null results with startle, threat expectancy, or avoidance). This finding coheres well with the spate of empirical findings showing that hoarding symptoms have divergent clinical (e.g., Bloch et al., 2014) and neurobiological correlates (e.g., Mataix-Cols et al., 2004) relative to other OCD symptoms, as well as with the more recent decision to relegate Hoarding to its own independent diagnosis (American Psychiatric Association, 2013). These findings build upon this past work by suggesting that Hoarding symptoms perhaps also diverge from other OCD symptoms by not conferring the inflated perception of improbable event likelihood deemed central to the development of SIC.

Conclusions

The current study represents the first lab-based test of whether OCD is linked with a heightened sensitivity toward improbable, catastrophic events. Results showed that individuals with higher OCD symptoms became more likely to avoid improbable threats the more averse they are to their consequences, and also exhibit greater levels of threat expectancy and startle formore improbable threats. Such results offer initial empirical validation for the observation that a variety of common OCD-relevant concerns involve improbable, catastrophic consequences, andfurther implicate a more general sensitivity toward improbable threat as the underlying deficit driving this phenomenon

Chapter 4: Replication and Extension to Disgust-Related Threats (Study 2)

Results from the first study offered preliminary evidence that OCD symptom confer increased threat responding to scenarios involving highly improbable and aversive consequences.A strength of this study was the use of a non-OCD-relevant threat, electric shock, which circumvented the circularity introduced by using a threat that is already known to elicit elevations in OCD symptoms. Although electric shock is undoubtedly an improvement over the use experimental threats directly implicated in OCD, it is still limited by the fact that it is circumscribed to physical danger. This limitation is particularly important for identifying the psychological contributors of OCD symptoms, which are often also characterized by strong feelings of disgust (Sieg and Scholz, 2001; Berle & Phillips, 2006; Knowles, Jessup, & Olatunji, 2018) in addition to desires to prevent harm. Indeed, both disgust-avoidance (i.e., desire to prevent the feeling of disgust) and harm-avoidance (i.e., desire to prevent a specific harmful event) have been identified as core motivational components in OCD patients with contamination fears (Melli, Chiorri, Carraresi, Stopani, & Bulli, 2015).

The Role of Disgust in OCD

Support for the role of disgust in OCD comes from a number of different sources. First, correlational studies have shown that those with elevated OCD symptoms are often also higher on disgust-related personality traits. For instance, Thorpe, Patel, and Simonds (2003) found that levels of disgust propensity significantly predicted OCI-R scores in a clinical sample,

with scores from the Washing subscale emerged as the most strongly predicted. Similar results have been obtained with non-clinical samples, where links between contamination fears and disgust have been found independent of anxiety and depression (Mancini, Gragnani, & D'Olimpio, 2001; Mortetz & McKay, 2008). Other studies suggest that disgust-related traits may also be elevated among individuals with OCD symptoms other than contamination/washing. For instance, Tolin,Woods, and Abramowitz (2006) found that disgust proneness significantly predicted ordering and checking symptoms from the OCI-R in addition to washing symptoms. Similarly, disgust- sensitivity significantly predicted levels of religious obsessions in a student sample, even after controlling for levels of contamination concerns and general fearfulness (Olatunji, Tolin, Huppert, & Lohr, 2005), while Muslim individuals with high scrupulosity have reported higher levels of disgust proneness after exposure to disgust-inducing images (Inozu, Ulukut, Ergun, & Alcolado, 2014). Thus, dispositional tendencies toward experiencing disgust may play a role in OCD more broadly, while also being particular relevant to the contamination subtype.

Experimental studies have also implicated a link between OCD and heightened disgust- responses. In one study, Nicholson and Barnes-Holmes (2012) found relations between OCI-R scores and implicit associations to disgust-relevant stimuli, as indexed by greater latencies (i.e., reaction times) when tasked with appraising a disgust-related picture as not disgusting. In this study, relations between disgust responses and the Washing and Obsessing

subscale of the OCI- R emerged as particularly strong. Similarly, Olatunji, Tolin, Huppert, and Lohr (2005) found that participants with high symptoms of contamination OCD exhibited less compliance across behavioral avoidance tests (BATs) involving contact with disgust-relevant stimuli (e.g., touching rotting food, stained underwear, earthworms etc.). as well as greater disgust responses when exposed to disgust-inducing images. Finally, OCD patients have also been found to exhibit greater self-reported (but not physiologically-measured) disgust to images of bodily waste relative to anxious and healthy controls. (Whitton, Henry, & Grisham, 2015). Thus, experimental studies back up the findings of correlational investigations by showing that personswith higher OCD symptom also exhibit heightened responses to disgust-related manipulations.

The Relevance of Disgust-related Responses to SIC

Given the prominent role of disgust in OCD, it is clearly important to test whether OCD symptoms predict heightened responses to anxiety- and disgust-provoking improbable catastrophes alike. This is particularly important given that fear—the primary emotion provoked by the potential of harm—is associated with a different behavioral and physiological response pattern compared to disgust. For instance, heart rate acceleration is thought to characterize fear while *deceleration* is thought to characterize disgust (Woody & Teachman, 2000). Similarly, while fear appears to enhance visual detection and processing, consistent with needing to attend quickly to threat, disgust suppresses visual attention and detection, consistent with it functioning to

minimize contact with contagious objects (Krusemark & Li, 2011). Additionally, some studies suggest that disgust does not habituate (i.e., decrease) with continued exposure to a threatening situation in the same way that fear does (Smits, Telch, & Randal, 2002; Olatunji, Wolitzky- Taylor, Willems, Lohr, & Armstrong, 2009), as measured by subjective report during in-vivo exposure exercises. Finally, even though disgust- and fear-induced behaviors are both assessed using similar measures like the BAT, many researchers contend that they prime different kinds of avoidance. More specifically, while fear may motivate the immediate fight-or-flight response, disgust may promote a more gradual back-away-slowly type of response (Susskind et al., 2008; van Hoof, Devue, Vieweg, & Theeuwes, 2013), consistent with disgust-inducing scenarios (e.g., dead animals, feces) involving dangerous but stationary objects.

Despite these differences, there is reason to suspect that OCD symptoms may confer increased sensitivity to disgust-related improbable catastrophes the same way they do to harm- related ones. Phenomenologically, disgust-related threats may involve improbable catastrophesthe same way that harm-provoking ones do. For instance, many forms of contamination OCD involve fears of an improbable catastrophe with a strong disgust component, as evidenced fears of coming into contact with contagions capable of conferring a serious illness (e.g., HIV) or a morally repugnant person who may transfer their untoward characteristics (Coughetry et al., 2013). Indeed, in some cases of contamination OCD, the improbable catastrophe is the

disgust response itself, which the patient fears will endure interminably following contact with a dirty/contaminated object (Abramowitz, 2006).

There is also evidence that OCD patients exhibit the same heightened expectancy for improbable disgust-related threats as was found for electric shock in the first study. As reviewed in Chapter 1, Tolin et al. (2004) found that OCD patients rated a neutral object (a pencil) as more contaminated compared to healthy and anxious controls, but only when it was farther downa chain of contagion. More specifically, OCD patients showed similar contamination ratings to the other groups for a pencil that had been rubbed directly onto a contaminated object, but *higher*ratings for the pencil that had been rubbed onto the first pencil (pencil #2), and for the pencil thathad been onto *that* pencil (i.e., pencil #3), etc. These results may be interpreted as those with OCD overestimating the probability of improbable disgust-related threats (i.e., pencils farther down the chain of contagion), but not more probable disgust-related threats (i.e., the first pencil in the chain of contagion) relative to healthy and anxious controls. As such, individuals with OCD may demonstrate the same heightened perception of likelihood for improbable, disgust- inducing threats in the same way they do for harmful ones. Given that this probability overestimation is proposed to be the driving feature behind SIC, participants with elevated expectancy of improbable, disgust-related outcomes may also exhibit heightened anxiety and avoidance for these threats when they are appraised as subjectively very aversive.

The Current Study

Given these considerations, the purpose of this second study was to a) re-test whether OCD symptoms confer increased threat expectancy for improbable threats and increased anxiousreactivity toward improbable, highly aversive ones, and b) test if these relationships are similar across a harm-related threat (i.e., electric shock) and a disgust-related threat (i.e., an 8s video of someone vomiting). Consistent with the purported sensitivity to improbable catastrophe being generalizable across all threats, I hypothesized that OCD symptoms would predict increased threat expectancy of both harmful and disgust-provoking improbable threats, as well as increasedanxious reactivity (avoidance, startle EMG) among those with higher aversion to such threats. Finally, because disgust appears to play a particularly important role in contamination OCD, I predicted that washing symptoms would produce the strongest effects in tests involving disgust-related threats. These analyses should help further clarify whether OCD symptoms confer increased sensitivity to improbable, catastrophic consequences by assessing whether this sensitivity is consistent across threats involving both disgust and physical harm.

Method

Participants

Participants were adult undergraduate students aged 18 – 65 who were originally recruited for two larger studies on personality traits and fear conditioning: One that utilized the original PIG paradigm (n = 422) and one that utilized an adapted disgust-version (n = 113). All inclusion criteria were identical to the first study (see Chapter 2, Section 2.2). Because average threat

aversion ratings (i.e., subjective rating of how important it was to not receive the experimental threat) were far higher in the shock condition (M = 5.94, SD = 3.52) compared to the disgust condition (M = 2.99, SD = 3.34), random subsets of participants from each condition were selected so as to match the conditions on mean threat aversion ratings. Additionally, no participants were selected who met the exclusion criteria listed in the first study, including a failure to distinguish CS+ from CS- during the Test phase or triggering a validity item embedded within the online surveys. Finally, no participants were selected from the shock condition that had been included in previously published data sets (i.e., Hunt et al., 2017; Hunt et al., 2019).

This selection procedure resulted in a total sample of 203 participants, including 134 for the shock condition and 69 for the disgust condition. The samples did not differ in terms gender, age,mean OCI-R scores, or perceived threat aversion ratings (see Table 4.1 below).

Table 4.1: Sample Characteristics for Shock and Disgust Conditions.

Threat Condition	Sample Size	Percent Female	Mean Age (SD)	Mean OCI-R (SD)	Mean Threat Aversion (SD)
Shock	134	71.64%	20.46 (2.99)	19.48 (14.09)	4.05 (3.19)
Disgust	69	73.91%	19.39 (1.62)	18.75 (13.16)	3.97 (3.29)

Note. Shock and disgust conditions were identical except for the nature of the experimental threat (electric shock vs. 8s vomit video clip). Threat aversion ratings refer to participants' self-reported desire to not receive the experimental threat during the task. OCI-R = Obsessive Compulsive Inventory – Revised.

Questionnaires

The same questionnaires collected in study one were collected in this study (OCI-R, STAI- T). Individuals from the disgust condition were also administered the Disgust Propensity and Sensitivity Scale – Revised (Olatunji Cisler, Deacon, Connolly, & Lohfr, 2007), which was used totest if effects with the OCI-R were the result of more general disgust-related dispositions.

Physiological Apparatus

Startle-blink EMG was elicited and recorded with an identical system and procedureas study one (see Chapter 2, Section 2.2).

Experimental Paradigm

Shock version. The shock condition of the PIG paradigm was identical to the original task developed by van Meurs et al. (2014). Full details can be found in Chapter 2, Section 2.2. Notably, this original version is different from the adapted version described in chapter 3, in that a) it utilizes only a single, 1-shock condition (i.e. 1 shock is possible when taking the short path) as opposed to additional 2- and 3-shock conditions, and b) assesses risk ratings on half of Pavlovian instrumental using a 3-point scale (i.e., 0 = “no risk”, 1 = “some risk”, 2 = “high risk”) as opposed to the 10-point scaled anxiety and shock expectancy ratings that were collected on every Pavlovian trials.

Disgust version. The disgust version of the PIG was identical to the original shockversion except for the graphics, experimental threat, and story provided to participants. Specifically, participants in the disgust version were told that the short road often passed roadkill, which depending on the direction of the wind (i.e., presentation of the

CS+) could blow toward the farmer and cause him to become sick. On both Pavlovian and Instrumental trials when the CS+ was presented, an image of wind is depicted beside the short road coincident with an image of the virtual farmer vomiting (see Figure 4.1 below). This image was presented coincident with a 6 s video clip of a real person vomiting superimposed over the CS+. The videoclip has been used in previous studies disgust-conditioning (Olatunji, Berg, Cox, & Billingsley, 2017). As in the original version, the actual experimental threat (i.e., video) is only presented on 50% of Pavlovian trials and 100% of Instrumental trials when the participants takes the short path, while the virtual vomit image is shown on 100% of both Pavlovian trials and Instrumental trials when the short path is taken. Throughout the disgust version, a research assistant observed the participants through a camera attached to the computer monitor to ensure the video clip was viewed in its entirety.

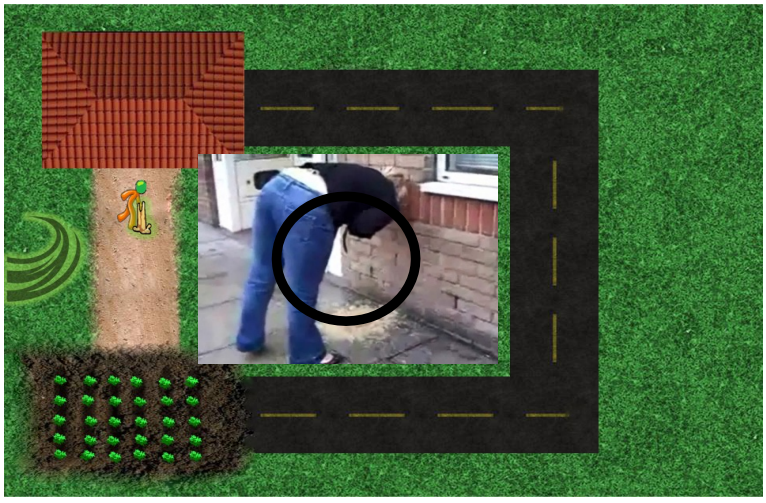


Figure 4.1. Example graphic of CS+ trial for the disgust version of the PIG paradigm. The disgust version was identical to the shock version except for the graphics, story, and experimental threat. Participants were told that on some trials, taking the short road would resultin the wind blowing the smell of

roadkill to the path and causing the farmer to vomit. PIG = Pavlovian and Instrumental Generalization; CS+ = Conditioned danger cue.

Procedure

The procedure in this study was identical to that of the first study (see Chapter 2, Section 2.2), except that: a) the shock work-up procedure for the shock condition involvedonly one shock, which was adjusted so that it was rated as highly uncomfortable but not painful (rated as a 3 on a scale of 0 to 5), and b) only one set of self-report ratings for the Test phase were collected, which occurred immediately after the conclusion of the experiment.

Data Analysis

Processing and manipulation checks. Startle EMG was processed in an identicalfashion as the first study. Risk ratings and startle EMG during Preacquisition and Acquisition were separately averaged for each stimulus type and then analyzed with separate 3-level (Stimulus type: ΔCS-, CS-, CS+) x 2-level (Threat condition: Shock, Disgust) rANOVAs. Risk ratings, startle EMG, and avoidance choices during the Test phase were separately averaged for each stimulus type and analyzed with separate 6-level (ΔCS-, CS-, GS_1, GS_2, GS_3, CS+) x 2-level (Threat condition: Shock, Disgust) rANOVAs. Significant stimulus x condition interactions were followed-up by examining pairwised differences for each stimulus type between the two conditions.

Main analyses. For the main analyses, separate hierarchical linear

regression models were built to test whether each response collected during the Test phase (avoidance choices,risk ratings, and startle EMG) could be predicted by OCI-R, threat aversion ratings, threat condition, and their interactions. OCI-R scores were entered in the first step to assess the main effect of OCD symptoms on threat responding. Threat aversion ratings and threat condition were entered next, followed by each of the constituent two-way interactions between the preceding variables (OCI-R x threat aversion; OCI-R x threat condition; threat aversion x threat condition). The three-way OCI-R x threat aversion x threat condition interaction was entered in the final step.

To simplify interpretations, within-subject differences in stimulus type were not assessed in this study so as to avoid testing 4-way interaction (i.e., stimulus type, x threat aversion rating x OCI-R x threat condition). Instead, average responding to stimuli in the improbable threat cluster (ΔCS-, CS-, GS_1) and the more probable threat cluster (GS_2, GS_3,CS+) were tested separately as outcomes, given that results from both Study 1 and past studies (Hunt et al., 2017; Hunt et al., 2019) supported this dichotomization on the basis of perceived threat probability. All predictors were *z*-scored prior to analyses.

Consistent with the notion that OCD symptoms would predict heightened expectancy of improbable threat regardless of threat modality, it was hypothesized that risk ratings toward the improbable threat stimuli (but not the more probable threat stimuli) would be significantly

predicted by higher OCI-R scores, but not the OCI-R x threat condition interaction. It was also predicted that startle EMG and avoidance choices for improbable threat stimuli (but not more probable threat stimuli) would be significantly predicted by the OCI-R x threat aversion interaction, but not the three-way OCI-R x threat aversion x threat condition interaction, consistent with OCD symptoms predicting heightened anxiety and avoidance to improbable, highly aversive threats regardless of modality.

All significant interactions were followed up with simple slopes calculated with thePROCESS Macro for SPSS (Hayes, 2012), which tests the influence of one variable (the predictor) at low (-1 *SD*) and high (+1 *SD*) levels of the other variable (the moderator). Since threat-condition contained only two levels, it was utilized as the moderator for all its significant interactions. For interaction interactions involving OCI-R and threat aversion, OCI-R was utilized as the moderator. Three-way interaction were broken down by testing the influence of threat aversion ratings at high and low levels of OCI-R separately for the disgust and shock conditions.

To ensure significant effects with OCD symptoms were not driven by more anxious-or disgust-related dispositions in general, significant effects within each condition were re- tested controlling for levels of STAI-T trait anxiety (shock condition) or DPDS Disgust Propensity (disgust condition).

Subscale analyses. Finally, to examine whether specific OCD symptoms were contributing to significant effects, the same analytic plan above was rerun replacing OCI-R scores with each symptom subscale: Washing, Checking, Ordering, Obsessing, Hoarding, and Neutralizing. For these analyses, it was predicted that washing symptoms would be associated with a significant 3-way interaction for startle EMG and avoidance, which wouldbe driven by a significantly greater OCI-R Washing x threat aversion rating in the disgust condition relative to the shock condition. No other explicit hypotheses were made for any other OCI-R subscale and their tests are considered exploratory. Alpha was set at 0.05 (two-tailed) for all statistical tests.

Results

Pre-acquisition

Prior to conditioning, no differences across stimuli (ΔCS- , CS-, CS+) were detected in terms of or startle EMG (p = .19) or risk ratings (p = .84). The stimulus x condition interactionwas also not significant for startle EMG (p = .57) or risk ratings (p = .26), indicating null differences between stimuli prior to acquisition did not differ across threat conditions.

Acquisition

During Acquisition, main effects of stimulus type were found for both startle EMG, $F(2,188) = 11.92$ $p < .001$, $\eta^{\$} = 0.06$, and risk ratings, $F(2, 198) = 593.60$, $p < .001$, $\eta^{\$} = 0.86$. Pairwise comparisons between stimuli revealed that the CS+ elicited greater startle (M = 52.22, SD = 4.79) compared to the

CS- (M = 50.17, SD = 3.76; p < .001) and $\Delta CS_{\#}$ (M = 50.53, SD = 4.51; p < .001), which did not differ from each other (p = .61). CS+ was also rated as more likelyto elicit threat (M = 1.54, SD = 0.41) compared to both the CS- (M = 0.27, SD = 0.39; p < .001) and the ΔCS- (M = 0.21, SD = 0.43; p < .001); CS- was also rated as slightly more likely to elicit threat compared to ΔCS-, t(1, 202) = 2.30, p = .026. The stimulus x condition interaction did not reach significance for startle, F(2, 188) = 2.18 p = .12, $\eta^{\$}$ = 0.026, or risk ratings, F(2, 198) =1.29, p = .28, $\eta^{\$}$ = 0.013, indicating that conditioning was similarly effective across both experimental conditions.

Test Phase

Risk Ratings. During the Test phase, risk ratings differed significantly as a function of stimulus type, F(5, 497) = 607.49, p < .001, $\eta^{\$}$ = 0.75, which was driven by a continuous decline in perceived shock as stimuli became more dissimilar from CS+ (linear decrease: F(1, 202) =1500.34, p < .001, $\eta^{\$}$ = .88; quadratic decrease: F(1, 202) = 512.15, p < .001, $\eta^{\$}$ = 0.72) Pairwise comparisons revealed that all stimuli from the improbable threat cluster (ΔCS- , CS-, GS_1) were a) rated as significantly less likely to result in shock compared to stimuli from the more probable threat cluster (GS_2, GS_3, CS+; ps < .001), and b) were not rated significantly differently in terms of shock risk from each other (ps > .15). Thus, stimuli continued to supportthe pre-planned

dichotomization of improbable and more probable threat clusters. The stimulus x threat condition interaction was not significant, $F(5, 198) = 1.97$, $p = .11$, $\eta^{\$} = 0.010$, indicating that differences between stimulus type did not differ between the shock and disgust conditions of the experiment (see Figure 4.2 below).

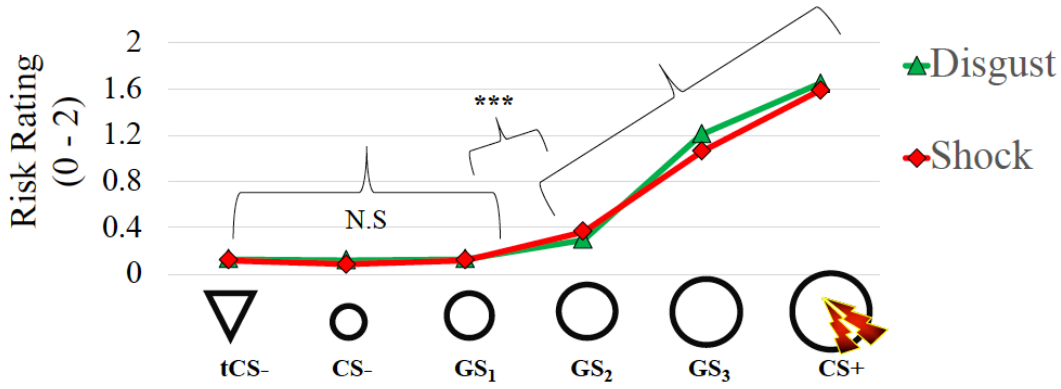


Figure 4.2. Differences between stimuli in terms of risk ratings between the disgust condition (green line) and shock condition (red line). The three stimuli least resembling CS+ (ΔCS-, CS-, GS_1) were all rated as significantly less likely to result in shock compared to the three stimuli most resembling CS+ (GS_2, GS_3, CS+), which were also not rated significantly differently from each other (ps > .15). Differences between stimuli did not vary significantly across conditions as indicated by a non-significant stimulus x condition interaction ($p = .11$). ΔCS- = triangular safety cue; CS- = circular safety cue' GS_{1-3}= generalization stimuli. CS+ = conditioned danger cue. N.S. = Not significant. ***p ≤ .001. $N = 203$.

Startle EMG. Startle EMG also differed significantly as a function of stimulus type, $F(5, 183) = 35.65$, $p < .001$, $\eta^{\$} = .16$, which was similarly driven by a continuous decline in startle as stimuli became more dissimilar from CS+ (linear decrease: $F(1, 188) = 64.47$, $p < .001$, $\eta^{\$} = .26$; quadratic decrease: $F(1, 188) = 39.70$, $p < .001$, $\eta^{\$} = .17$). Pairwise comparisons revealed that all stimuli from the improbable threat cluster (ΔCS- , CS-, GS_1) elicited significantly

smaller startle responses compared to stimuli from the more probable threat cluster (GS_2, GS_3, CS+; *p*s <.05). Within the improbable threat cluster, ΔCS- elicited significantly greater startle than CS-, $t(1, 188) = 2.11$, $p = .036$, but not at the Bonferroni-corrected *p*-value of .013. Within the more probable threat cluster, CS+ elicited significantly greater startle responses compared to GS_3, $t(1, 188) = 4.94$, $p < .001$, which in turn elicited greater startle responses than GS_2, $t(1, 188) = 5.76$, $p < .001$. The stimulus x threat condition interaction was also significant for startle, $F(5, 183) = 10.72$, $p < .001$, $\eta^2 = 0.054$. Pairwise comparisons revealed that this effect was driven by there being significantly greater startle in the shock condition relative to the disgust condition for CS+, $t(1, 188) = 3.90$, $p < .001$, and GS_3, $t(1, 188) = 3.93$, $p < .001$.

Avoidance choices. During the Test phase, risk ratings differed significantly as a functionof stimulus type, $F(5, 197) = 159.75$, $p < .001$, $\eta^2 = 0.44$, which was again driven by a continuous decline in the number of avoidance decisions committed as stimuli became more dissimilar from CS+ (linear decrease: $F(1, 202) = 220.42$, $p < .001$, $\eta^2 = 0.52$; quadratic decrease: $F(1, 202) = 126.79$, $p < .001$, $\eta^2 = 0.39$). Pairwise comparisons showed that all stimuli from the improbable threat cluster (ΔCS- , CS-, GS_1) a) were avoided significantly less than allstimuli from the more probable threat cluster (GS_2, GS_3, CS+; *p*s < .001), and b) did not differ differently in avoidance levels from each other (*p*s > .44). Like risk ratings, the stimulus x threat condition interaction was not significant, $F(5, 198) = 0.19$ $p = .80$, $\eta^2 = 0.001$, indicating that differences

between stimulus types did not differbetween the shock and disgust conditions of the experiment.

Main Analyses

Full statistics for models predicting responses (risk ratings, startle, avoidance) to improbable threat stimuli and more probable threat stimuli can be found below in tables 4.2 and 4.3, respectively.

Table 4.2: Regression Model Statistics for Improbable Threat Responses

Dependent Variable	Step	Predictor	F	ΔR^2	β	p
Risk Ratings	1	OCI-R	12.73	.060	0.24	<.001
	2		3.00	.028		.052
		Aversion Ratings			0.17	.017
		Threat Condition			-0.03	.65
	3		0.93	.013		.43
		OCI-R x Aversion			0.08	.23
		OCI-R x Condition			-0.21	.41
		Aversion x Condition			0.20	.43
	4	OCI-R x Aversion x Condition	2.29	.010	0.35	.13
Startle EMG	1	OCI-R	1.08	.006	-0.08	.30
	2		0.09	.001		.91
		Aversion Ratings			0.07	.92
		Threat Condition			-0.03	.68
	3		0.40	.007		.75
		OCI-R x Aversion			-0.02	.81
		OCI-R x Condition			0.28	.31
		Aversion x Condition			-0.05	.99
	4	OCI-R x Aversion x Condition	0.31	.002	0.14	.58
Avoidance Choices	1	OCI-R	4.84	.024	0.15	.03
	2		10.25	.090		<.001
		Aversion Ratings			0.30	<.001
		Threat Condition			0.07	.32
	3		5.44	.068	0.23	.001
		OCI-R x Aversion			0.19	.005
		OCI-R x Condition			0.34	.16
		Aversion x Condition			0.62	.009
	4	OCI-R x Aversion x Condition	8.18	.033	0.62	.005

Note. Improbable threats are indexed as the average response (risk ratings, startle EMG, avoidance choices) to the three stimulus classes most dissimilar from the

conditioned danger cue(i.e, ΔCS-, CS- and GS_1). Condition refers to the type of experimental threat participants were atrisk for – electric shock or disgust. Positive beta weights reflect greater responding in the shock vs. the disgust condition Aversion ratings refer to participants' self-reported desire to not receivethe experimental threat during the task. OCI-R = Obsessive Compulsive Inventory – Revised. *N*= 203

Table 4.3: Regression Model Statistics for More Probable Threat Responses

Dependent Variable	Step	Predictor	*F*	ΔR^2	β	*p*
Risk Ratings	1	OCI-R	0.70	.003	0.06	.40
	2		13.36	.12		<.001
		Aversion Ratings			0.34	<.001
		Threat Condition			-0.06	.40
	3		1.79	.023		.15
		OCI-R x Aversion			0.10	.15
		OCI-R x Condition			0.05	.85
		Aversion x Condition			0.46	.063
	4	OCI-R x Aversion x Condition	1.59	.007	0.29	.21
Startle EMG	1	OCI-R	1.22	.006	-0.08	.27
	2		7.46	.074		.001
		Aversion Ratings			-0.05	.48
		Threat Condition			0.27	<.001
	3		0.40	.007		.75
		OCI-R x Aversion			-0.02	.81
		OCI-R x Condition			0.28	.31
		Aversion x Condition			-0.05	.99
	4	OCI-R x Aversion x Condition	0.31	.002	0.14	.58
Avoidance Choices	1	OCI-R	4.84	.024	0.15	.03
	2		10.25	.090		<.001
		Aversion Ratings			0.30	<.001
		Threat Condition			0.07	.32
	3		5.44	.068	0.23	.001
		OCI-R x Aversion			0.19	.005
		OCI-R x Condition			0.34	.16
		Aversion x Condition			0.62	.009
	4	OCI-R x Aversion x Condition	8.18	.033	0.62	.005

Note. More probable threats are indexed as the average response (risk ratings, startle, avoidance)to the stimulus classes with greatest similarity to the conditioned danger cue (i.e, GS_2, GS_3, and CS+). Condition refers to the type of experimental threat participants were at risk for – electric shock or disgust. Positive beta weights reflect greater responding in the shock vs. the disgust condition. Aversion ratings refer to participants' self-reported desire to not receive the experimental threat during the task. OCI-R = Obsessive Compulsive Inventory – Revised.

Risk ratings. As predicted, OCI-R scores predicted greater expectancy of improbable threat ($p < .001$). Further, this effect did not differ as a function of the experimental condition ($p = .41$), which simple slopes revealed was driven by greater OCD symptoms predicting higher expectancy of improbable threat in both the disgust condition, $\beta = 0.34$ $t(202) = 3.04$, $p = .0027$,and the shock condition, $\beta = 0.19$, $t(202) = 2.15$, $p = .033$ (see Figure 4.4 below). Moreover, theOCI-R x threat aversion interaction was also not significant ($p = .23$), indicating that those with greater OCD symptoms tended to overestimate the chance of improbable threat regardless of how aversive they found it.

In contrast, OCI-R scores did not significantly predict heightened threat expectancy of more probable threat stimuli ($p = .40$), which did not vary significantly across conditions ($p = .85$) or levels of threat aversion ($p = .15$).

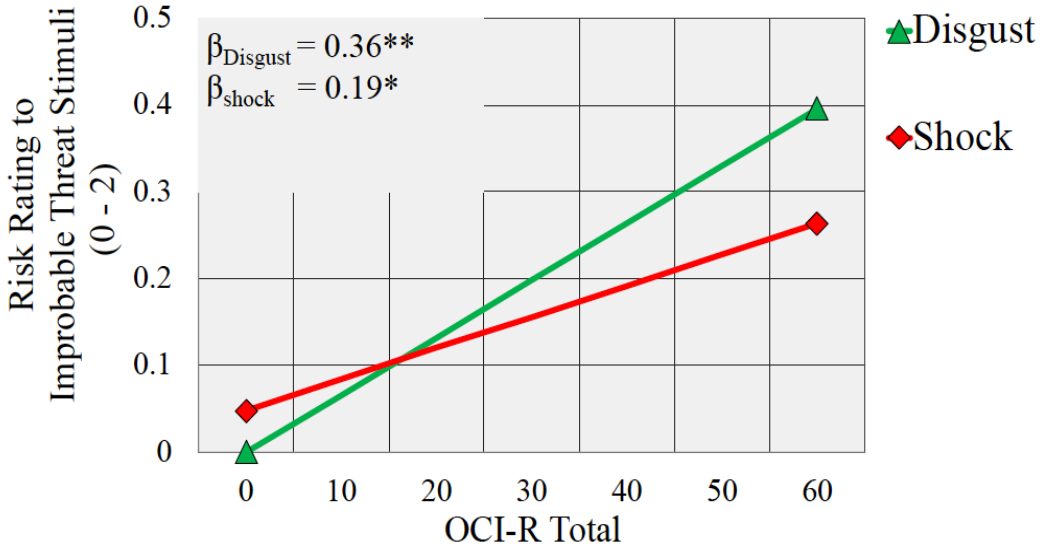


Figure 4.3. Effect of OCI-R scores on improbable threat risk ratings across experimental conditions. Improbable threat stimuli are the three stimuli that are most dissimilar from the conditioned danger cue (i.e., ΔCS-, CS-, GS_1). Disgust and shock conditions were identical except for the nature of the

experimental threat (electric shock vs. vomit video clip). OCI-R = Obsessive Compulsive Inventory – Revised. *$p \leq .05$; **$p \leq .01$. $N = 203$.

Startle EMG. Contrary to predictions, startle to improbable threat was not significantlypredicted by any independent variable, including OCI-R or the OCI-R x threat aversion interaction (*p*s > .31). Similarly, no independent variable emerged as a significant predictor ofstartle to more probable threat stimuli (*p*s > .27), with the exception that startle was greater for the shock condition relative to the disgust condition ($p < .001$).

Avoidance choices. Consistent with predictions, avoidance of improbable threat was significantly predicted the OCI-R x threat aversion interaction ($p = .005$), such that perceived aversion was a better predictor of improbable threat avoidance by those with higher OCI-R scores. Avoidance of improbable threat was also significantly predicted by the three-way OCI-R x threat aversion x threat condition interaction ($p < .001$), which was driven by a significant OCI-R x threat aversion interaction for the shock condition, $F(3,199) = 12.59$, $R^2 = .074$, $p = .001$, but not the disgust condition, $F(3,199) = 0.005$, $R^2 = .005$, $p = .56$. Simple slopes further revealed that threat aversion predicted avoidance of improbable threat for the shock condition at high (+1 *SD*) levels of OCI-R, $\beta = 0.75$, $t(202) = 5.79$, $p < .001$, but not low (-1 *SD*) levels of OCI-R, $\beta = 0.074$, $t(202) = 0.56$, $p = .58$. In contrast, threat aversion did not significantly predict avoidance of improbable threat in the disgust condition at high levels of OCI-R, $\beta = 0.047$, $t(202) = 0.52$, $p = .60$ or low levels of OCI-R, $\beta = 0.12$, $t(202) = 1.23$, $p = .22$.

Avoidance of more probable threat was not significantly predicted by OCI-R scores (p = .49), or the OCI-R x threat aversion interaction (p = .26); however, the OCI-R x Threat aversion x Threat condition interaction was marginally significant (p = .064). More probable threats were also predicted by the OCI-R x Threat Condition interaction (p = .01) and the Threat Aversion x Threat Condition interaction (p = .006), indicating that OCI-R scores and threat aversion ratings were more predictive of probable threat avoidance in the shock condition relative to the disgust condition. Simple slopes of relations between threat aversion and avoidance for each OCD group (low vs. high) and threat probability cluster are shown in Figure 4.4.

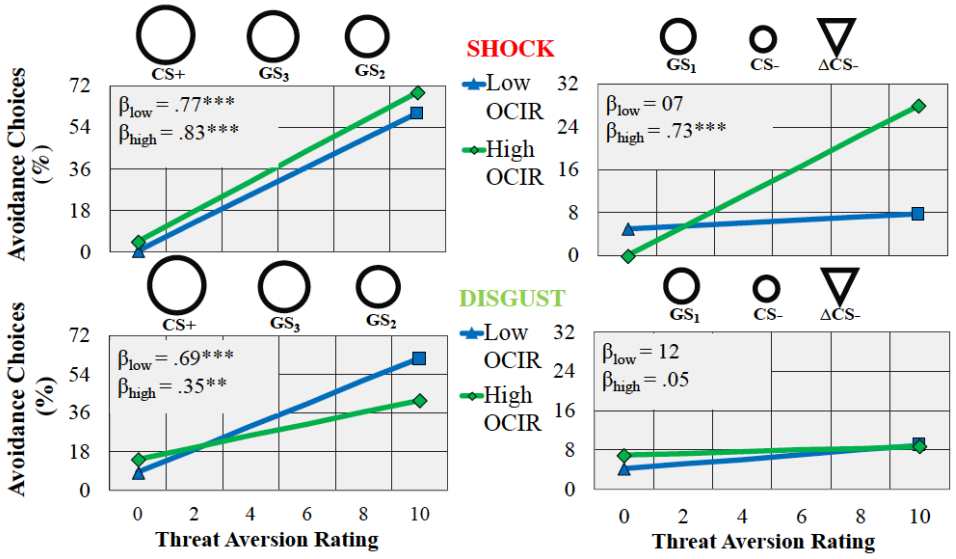


Figure 4.4. Interactive effects of OCI-R scores and threat aversion ratings across stimulus probability clusters and experimental conditions. More probable threat stimuli (left) are the threestimuli most similar to the conditioned stimulus (i.e., CS+, GS_3, GS_2) and improbable threat stimuli (right) are the three stimuli most dissimilar from the conditioned danger cue (i.e., ΔCS-, CS-, GS_1). Shock (top) and disgust (bottom) conditions were identical except for the nature of the experimental threat (electric shock vs. vomit video clip). Threat aversion ratings refer to participants' self-reported desire to not receive the experimental threat during the task. OCI-R = Obsessive Compulsive Inventory – Revised. **$p \leq .01$; ***$p \leq .001$. N = 203.

Testing specificity to OCD Symptoms

Next, to test whether significant effects with OCI-R for risk ratings and avoidance were attributable to OCD symptoms as opposed to broader levels of anxiety- or disgust-related personality traits, significant models were re-run controlling for levels of trait anxiety (STAI-T) and Disgust Propensity (DPSS-DP). For the shock condition, OCI-R remained a significant predictor of risk ratings to improbable threat, $\beta = 0.19$, $t(133) = 2.11$, $p = .037$, and avoidance ofimprobable threat, $\beta = 0.19$, $t(132) = 2.12$, $p = .036$, after controlling for STAI-T scores. The OCI-R x threat aversion interaction also remained a significant predictor of improbable threat avoidance after controlling for STAI-T, $\beta = 0.27$, $t(130) = 3.37$, $p = .001$. In contrast, OCI-R scores became only a marginally significant predictor of improbable threat risk ratings for the disgust condition when controlling for DPSS-DP scores, $\beta = 0.23$, $t(133) = 1.91$, $p = .061$. DPSS-DP scores also emerged as a strong and significant predictor of improbable threat riskratings for the disgust condition, $\beta = 0.38$, $t(133) = 3.33$, $p = .001$.

Testing Effects with OCI-R Subscales

Finally, to examine if significant results with overall OCI-R were driven by particular subscales, the a) significant effect of OCI-R on improbable threat risk ratings, b) significant effect of OCI-R on avoidance of improbable threat, and c) the OCI-R x threat aversion interaction on avoidance of improbable threat were re-tested replacing overall OCI-R with each OCI-R subscale (Washing, Checking, Neutralizing, Ordering, Obsessing, Hoarding).

The full set of OCI-R subscale results can be found below in Table 4.4.

Table 4.4: Regression model statistics for OCI-R subscales.

Dependent Variable	Condition	OCI-R Subscale Predictor	*F*	ΔR^2	β	*p*
Risk Ratings to Improbable Threat	Disgust	Washing	5.93	.081	0.29	.018
	Shock		3.29	.024	0.16	.072
	Disgust	Checking	4.60	.064	0.25	.036
	Shock		7.10	.051	0.23	.009
	Disgust	Neutralizing	5.60	0.077	0.28	.021
	Shock		1.00	.008	0.09	.32
	Disgust	Ordering	4.23	.059	0.24	.044
	Shock		0.77	.006	0.08	.38
	Disgust	Obsessing	10.66	.14	0.37	.002
	Shock		5.78	.042	0.21	.020
	Disgust	Hoarding	5.32	.074	0.27	.024
	Shock		2.21	.016	0.13	.14
Avoidance of Improbable Threat	Disgust	Washing	2.37	.034	0.19	.13
	Shock		4.17	.031	0.18	.043
	Disgust	Checking	0.56	.008	0.09	.46
	Shock		2.12	.016	0.13	.15
	Disgust	Neutralizing	0.008	0.000	0.011	.93
	Shock		1.96	.015	0.12	.16
	Disgust	Ordering	0.72	.011	0.10	.40
	Shock		0.005	.000	-0.007	.94
	Disgust	Obsessing	1.81	.026	0.16	.18
	Shock		3.93	.029	0.17	.049
	Disgust	Hoarding	0.24	.004	0.060	.63
	Shock		7.05	.051	0.23	.009
Avoidance of Improbable Threat	Disgust	Washing x Aversion	0.65	.009	-0.10	.42
	Shock		11.83	.070	0.27	.001
	Disgust	Checking x Aversion	0.43	.006	-0.08	.51
	Shock		4.17	.027	0.16	.043
	Disgust	Neutralizing x Aversion	0.12	0.002	-0.05	.73
	Shock		3.37	.022	0.15	.069
	Disgust	Ordering x Aversion	1.81	.026	-0.17	.18
	Shock		0.011	.000	-0.009	.92
	Disgust	Obsessing x Aversion	0.18	.003	0.058	.67
	Shock		9.15	.056	0.24	.003
	Disgust	Hoarding x Aversion	0.012	.000	0.015	.91
	Shock		31.98	.16	0.41	<.001

Note. Improbable threats are the three stimulus classes with least similarity to the conditioned danger cue (i.e, ΔCS-, CS-, GS_1). Condition refers to the type of experimental threat participants were at risk for (electric shock vs. vomit video clip). Aversion ratings refer to participants' self-reported desire to not receive the experimental threat during the task. OCI-R = Obsessive Compulsive Inventory – Revised. $N = 203$.

For risk ratings to improbable threat stimuli, all OCI-R subscales were significant for thedisgust condition (*p*s < .044), while only Checking ($p = .009$) and Obsessing ($p = .020$) were significant for the shock condition, as well as Washing at the level of a trend ($p = .072$). For avoidance of improbable threat,

no subscales were significant for the disgust condition (*p*s > .13), while Washing (*p* = .043), Obsessing (*p* = .049), and Hoarding (*p* = .009) were significantfor the shock condition. Similarly, none of the OCI-R subscale x Threat aversion interactions were significant predictors of avoidance in the disgust condition (*p*s > .18), while all subscales except for Ordering (*p* = .92) and Neutralizing (*p* = .069) interacted significantly with threat aversion in predicting avoidance of improbable threat in the shock condition (*p*s < .043). Thus, the hypothesis that Washing symptoms specifically would predict greater threat responding to the disgust condition was not supported.

Discussion

The purpose of this study was to examine whether relations between OCD symptoms and heightened anxious reactivity to improbable, highly aversive threats, as well as heightened expectancy to improbable threat more generally, would generalize across consequences involving disgust (i.e., vomit video clip) and physical danger (i.e., electric shock). Consistent with expectations, OCD symptoms predicted higher expectancy of improbable, but not more probable threats across both harm and disgust-related consequences. OCI-R scores also interacted with threat aversion to predict greater avoidance of improbable, but not more probable threats, indicating those with greater OCD symptoms were more likely to avoid specifically when facing improbable, highly aversive consequences. Unexpectedly however, this effect was specific to electric shock, as the main effect of OCD symptoms and its interaction with threat aversion did not predict avoidance of improbable threat

in the disgust condition. Moreover, OCD symptoms were not associated with higher startle to improbable threat, regardless of levels of threat aversion, which was in contrast to both expectations and to results from the first study.

Interpreting Combined effects of Threat Probability and Aversion on Avoidance

The fact that perceived threat aversion again predicted avoidance of improbable threat specifically among those with higher OCI-R scores offers further validation that OCD involves asensitivity to improbable, catastrophic threats. Confidence in this effect is further buttressed by the fact that it was consistent despite the presence of key methodological differences between the experimental paradigms used in the two studies (e.g., number of shocks possible, number of total trials). Contrary to expectations however, OCD symptoms did not predict increased avoidance ofimprobable, subjectively aversive, disgust-related threats. This was a surprising finding, as many common improbable catastrophes associated with OCD have a clear disgust-component (e.g., those associated with contamination OCD). More broadly, this finding goes against the theory that specific type of threat should not influence whether or not those with OCD are sensitive to improbable catastrophes. Specifically, the diverse array of improbable catastrophes associated with OCD implies that the specific modality of the threat makes little difference as to whether those with OCD are sensitive to such events—a notion that was contradicted in the present study.

There are two possible reasons for why OCD symptoms did not

predict avoidance of improbable, highly aversive disgust-related threats in the present study. First, avoidance in the PIG paradigm may not be a good match for the sort of avoidance disgust primes (Cisler et al., 2009). Specifically, disgust is believed to prompt more gradual and subtle avoidance behaviorslike withdrawing distancing, stopping, or dropping of contaminated objects to reduce contact with communicable diseases (Curtis, De Barra, & Aunger, 2011) whereas fear is known to prompt more sudden flight-like behaviors useful for feeling from active threats. The avoidance scenario instantiated in the PIG paradigm is arguably a much better fit for the latter, fear-related avoidance: The farmer is encountered with a potential threat (e.g., a CS+) and has the option to flee (i.e., take the long path). Moreover, in the disgust version of the experiment, the farmer (or the participant) is not faced with the potential of coming into *contact* with a disgust-related threat (i.e., human vomit) but rather just the smell (for the farmer) and visual (for the participant) of an individual vomiting. Thus, disgust-related threat used in this experiment may not actually instantiate the very situation—contact with a potential contaminate—believed to be the primary driver of disgust-elicited avoidance (Davey, 2011).

The second reason why OCD symptoms might have predicted avoidance of improbable, highly aversive harmful consequences, but not disgust-related ones, is that only the former outcome is theoretically preventable. Specifically, in the shock condition, participant could still prevent receiving electric by taking the long path, while the individual depicted in the

disgust video had already become sick. This difference between the two version is relevant given the heightened perceptions of responsibility for harm often associated with OCD (Salkovskis et al., 2000. As such, if the participant (mistakenly) perceived a stimulus as safe during the shock condition, they would be responsible for shock occurring to themselves, whereas they would notbe responsible for the individual in the video becoming sick regardless of whether they correctlyperceived danger. Regardless of whether these interpretations are correct, more research is clearly needed to elucidate if observed null relations between OCD symptoms and avoidance of disgust-related threats reflect a methodological artefact of the PIG paradigm or an indication thatSIC is indeed relatively circumscribed to harmful consequences.

Interpreting Null Effects for Startle

Unexpectedly, OCD symptoms did not predict startle to improbable threats for either condition, even for individuals reporting high threat aversion. Though surprising, null startle results for the disgust condition are at least consistent with past investigations, as researchers have thus far failed to link OCD to disgust-triggered physiological responding across any methodor task (Cisler et al., 2009). Moreover, across all participants, there was decreased differentiationin terms of startle for stimuli in the disgust condition, suggesting that startle was not as robustly modulated by threat probability when potentiated by disgust. Thus, the lack of relations between OCD symptoms and startle to improbable threat in the disgust condition may be a more global issue with attempting to find physiological differences of any kind to disgust-based

manipulations.

The lack of expected effects for startle in the shock condition was more surprising, as OCD symptoms had predicted startle to more improbable threat in study one. This difference could be due to the use of different statistical methods in these two studies. For instance, the significant effect in study one was an OCI-R x stimulus type interaction using the whole stimulusset, which may have been a more powerful procedure for finding OCD-related differences acrossstimuli. Another possibility, however, is that startle is simply a less reliable measure of anxiety/avoidance compared to behavioral indices. This notion is supported by the substantially lower internal consistency of standardized startle response in experimental paradigms (e.g., Bradford, Starr, Shackman, & Curtin, 2015) compared to overt behaviors in behavioral tasks (e.g., Lejuez et al., 2002).

Interpreting Independent Effects of Threat Probability and Aversion

As in study one, OCD symptoms were associated with greater avoidance and expectancy of more improbable threats. Moreover, effects with threat expectancy were consistent across boththe shock and disgust conditions, such that participants with higher OCD symptoms were more expectant of improbable threat regardless of the particular consequence. This finding adds further confidence to the notion that the driving force behind the development of improbable, catastrophic fears in OCD is a general tendency to overestimate improbable threats, which has been found repeatedly across a variety of experimental studies (Fear & Healy, 1997; Hermans et al., 2008; Foa et al.,

2001; Niemeyer et al., 2013 vs. Moritz & Jelinek, 2009). Further, across conditions, there was a) no significant OCI-R x threat aversion interaction, and b) no relationshipbetween OCD symptoms and expectancy of more probable threats. Together, these results strongly indicate that OCD is associated with a fairly focal tendency to overestimate the likelihood of improbable threats, which is present regardless of the nature or aversiveness of the particular outcome. Of note, the effect of OCI-R on risk ratings for improbable disgust-related threats became only marginally significant when controlling for disgust propensity. Thus, unlike risk for improbable shock-related threats, tendencies to overestimate improbable disgust-related threats in OCD may be more strongly mediated by certain disgust-related personality traits.

Like results from the first study, the degree of probability overestimation across both threat conditions in this investigation was again fairly slight. For instance, individuals with OCD symptoms +1*SD* above the mean rated the risk of shock as 0.2/2 on average, whereas those -1*SD* below the mean provided a rating of 0.1/1 on average. If converted to same scale used in the first study (i.e., percentages), these values are basically identical (i.e., 5% for -1 *SD* below the mean ;10% for +1 *SD* above the mean). As such, these results further indicate that OCD symptoms are associated with only marginal increases in the perception of improbable threat likelihood, which is again consistent with most patients possessing intact insight into the irrationality of their fears (e.g., Marazzti et al., 2002; Kishore, Samar, Reddy, Chandrasekhar, &Thennarasu, 2004 (Foa and Kozak, 1995; Tolin et al.,

2001).

Interpreting Effects for Specific OCD Symptom Presentations

Contrary to expectations, washing symptoms did not show particularly strong or specific relations to disgust-related threats. Specifically, washing symptoms did not predict increased startle or avoidance to improbable disgust-related threats, even when aversion to such threats washigher. This null result is surprising given that disgust-related threats figure prominently into the phenomenology of OCD patients with primary washing symptoms (e.g., Mancini et al. 2001; Mortetz & McKay, 2008).

One explanation for these findings is that participants with elevated washing symptoms in this sample were more motivated by avoidance of harm than by avoidance of disgust. Although both of these motivations are relevant explanations for OCD-relevant washing behavior (Melli etal., 2015), harm-related motivations appear to be more prevalent. For instance, in one OCD patient sample (N = 485), concerns with contracting a specific disease from a contaminant (i.e., avoidance of harm) were about twice as common as concerns pertaining only to how contacting that contaminant would *feel* (i.e., avoidance of disgust; Pinto et al., 2008). Therefore, it is feasible that the current sample was characterized by a greater number of participants possessing harm-related motivations for washing behavior compared to those possessing disgust-related motivations, thereby resulting in findings for the harm-related threat (i.e., electric shock) being stronger. Accordingly, it will be important for future research aimed at characterizing the null relations between washing symptoms

and disgust-related avoidance in the PIG paradigm to consider the specific motivations exhibited by participants with washing-related symptoms.

Nonetheless, washing symptoms were predictive of greater risk ratings to improbable disgust-related threats but not shock-related ones, and also evidenced the strongest relationship with expectancy of improbable disgust-related threats among the OCI-R subscales. Moreover, although no OCI-R subscale significantly predicted avoidance of improbable disgust-related threats, the effect of washing was again strongest among the subscales. Finally, the effect of washing on avoidance of improbable disgust- and shock-related threats was virtually identical ($\beta = 0.19$ for disgust; $\beta = 0.18$ for shock) whereas every other subscale had a much stronger effectin favor of the shock. Thus, although effects with washing were weaker than anticipated, there was at least some evidence that the subscale exhibited associations that are consistent with previously found relations between washing/contamination symptoms and responses to disgust-related threats (e.g., Olatunji et al., 2007; Nicholson & Barnes-Holmes, 2012).

Disappointingly, the subscale-specific patterns with threat responding found in this studywere markedly different from those found in the first study. For instance, while Washing and Checking symptoms were the only subscales to predict avoidance of improbable, highly aversive threats in the first study, such responses were also predicted by Obsessing and Hoarding in this study. Effects with Obsessing go against the interpretation that avoidance of improbable, highly aversive threats in the PIG paradigm may be best predicted

by OCD symptoms that similarly tapbehavioral (rather than mental) avoidance symptoms. Moreover, while Hoarding arguably taps behavioral responses (e.g., collecting/saving items), it has also repeatedly exhibited divergent clinical correlates with OCD (e.g., Bloch et al., 2014, implying it should only be weakly tied to aputatively OCD-specific process like SIC.

It is possible that specific methodological differences between studies one and two mayaccount for differing patterns of subscale effects. However, perhaps the most parsimonious explanation for these discrepancies is error associated with measurement of OCI-R subscales. Although the reliability and validity of the overall OCI-R scale is excellent, psychometric properties of the subscale are quite variable, at times dipping below the acceptable range in somestudies (Foa et al., 2002; Hajack et al., 2004; Abramowitz & Deacon, 2006). Therefore, extreme caution should be utilized in interpreting results with specific subscales, consistent with their findings being considered only exploratory in the present dissertation.

Conclusions

The aim of the current study was to replicate and extend the finding that OCD symptomspredicted heightened avoidance of improbable, highly aversive threats, and elevated expectancy of improbable threat more generally, by testing the invariance of these relations across threats involving both disgust and physical danger. Consistent with results from the first investigation, those with higher OCD symptoms were likely to avoid improbable threats if they are more averse to their consequences; however, these effects were specific to

harmful consequences. Additionally,participants with greater OCD symptoms appraised improbable threats as more likely to occur regardless of whether they involved disgust or harm, suggesting links between OCD symptoms and overestimations of improbable threat likelihood generalize across different kinds of aversive outcomes. Overall, these results further validate the observation that OCD involves a heightened tendency to avoid improbable, catastrophic consequences, but suggest that this relationship may also depend on the threat's potential to evoke harm. Moreover, results with threat expectancy offer further confidence that OCD involves a general sensitivity toward (slightly) overestimating the likelihood of improbable threats, which may be the core feature underlying the purported sensitivity to improbable catastrophes in the illness.

Chapter 5: Sensitivity to Improbable Catastrophes as a Risk Factor for OCD (Study 3)

Findings from the first two studies demonstrated that OCD symptoms are associated withincreased avoidance of improbable, highly aversive threats, as well as increased expectancy of improbable threats in general. While these findings implicate SIC as relevant to OCD, one issue they are unable to address is whether this sensitivity act as a risk factor for the disorder or merelya correlate. Clarifying this distinction, moreover, could important clinical implications for OCD. For instance, if SIC acts as a risk factor of OCD, it could be used to predict and ultimately prevent future manifestation of the illness. Moreover, since temporal precedence is one of the necessary components of causality (Chambliss & Schutt, 2018), establishing SIC as a risk factor could shed light on whether treatments designed to address this sensitivity would actually lead to reductions in OCD symptoms.

Disentangling if a variable represents a correlate or risk factor requires a longitudinal design. In the simplest longitudinal design, both the candidate risk factor (e.g., SIC) and the outcome (e.g., OCD symptoms) are measured at one time point while the outcome is measured again at a future time point (e.g., Leneart et al., 2014). If relations between the candidate variable and outcome are purely concurrent in nature (i.e., the candidate variable is merely a correlate), any variance the candidate variable shares with future levels of the outcome should be fully eclipsed when controlling for baseline levels of the outcome. However, if the candidate variable also functions as a risk factor, it

should predict additional unique variance in the outcome at follow-up above and beyond levels at baseline, such that *changes* in the outcome are associated with levels of the risk factor (Zvolensky, Schmidt, Bernstein, Keough, 2006).

Unfortunately, very little longitudinal exists that can speak to whether SIC functions as a risk factor or correlate of OCD pathology. The most relevant evidence comes from studies assessing prospective relations between OCD beliefs on the OBQ-44 and OCD symptoms. In thefirst of these studies, Coles and Horng (2006) found that OBQ scores predicted OCI-R scores six weeks later in a large sample of undergraduate students. This same group also found that the distress associated with OCD symptoms (i.e., the distress subscale of the original OCI) at 6-month follow-up was significantly predicted by baseline OBQ scores (Coles, Pietrefesa, Schofield, & Cook, 2008). In a slightly different sample, Abramowitz, Khandker, Nelson, Deacon, and Rygwall (2006) found that OBQ scores significantly predicted symptoms from the OCI-R and the Y-BOCS at 3-month follow-up for men and women who recently had their first child—a common trigger of OCD symptoms (Zambaldi et al., 2014). Together, these findings suggest that maladaptive OCD-relevant cognitions may act vulnerabilities markers for OCD symptoms. However, while there is some conceptual overlap OBQ-44 subscales and measures of SIC (e.g., tendency to overestimate threat), SIC is obviously a much more specific type of threat-based distortion, meaning it may have entirely different prospective relations with future OCD symptoms compared to more broad-band threat-related constructs.

First-semester college students offer an intriguing population in which to test for premorbid markers of OCD pathology. For one, identifying vulnerability markers of psychopathology by definition requires the use of a non-clinical sample that has not yet developed the illness (Leneart et al., 2014). Importantly however, most first-year college studentsare just prior to age that OCD is most likely to develop (Rasmussen & Eisen, 1992; Delorme et al., 2003), suggesting the onset of new pathology is this population is relatively high relative to other groups. Additionally, first-semester college students experience a variety of novel stressors (e.g., increased academic expectations, finding a new friend group), which combined with heightened expectation of autonomy may stimulate the development of new anxiety symptoms (Dyson & Renk, 2006; Gefen, 2010). Indeed, many aspects of collegiate life could be considered face-valid triggers for previously unexpressed OCD symptoms. For instance, the heightened prevalence of sexually-transmitted diseases (Koumans et al., 2005) and crowded or dirty public spaces (e.g., classrooms, dormitories) could bring newfound challenges to those with latent contamination OCD. Similarly, increased levels of responsible for protecting one's valuable possessions (e.g., laptops) could provoke formerly unprovoked checking behavior among those predisposed to such proclivities. Finally, the requirement of a shared living space could be highlydistressing for someone with marked preoccupations for symmetry and order, especially if paired with a roommate with relatively lax standards for organization and tidiness.

Given these considerations, the purpose of the current study was to test

whether responses to improbable, highly aversive threats in the PIG paradigm could prospectively predictlevels of future OCD symptoms across the first year of college. Since the first two studies implicated heightened responding to improbable threats as a marker of OCD symptoms across multiple threat response types, I predicted that each threat response (threat expectancy, anxiety, startle, and avoidance) to improbable threats, but not more probable threat, would act as a prospective predictor of OCD symptoms. Furthermore, I predicted that startle, anxiety, and avoidance for improbable threat would more strongly predict future OCD symptoms among participants with higher threat aversion, consistent with anxious reactivity in conditions most closely approximating improbable catastrophes being the most sensitive marker of future OCD symptoms. Such analyses should afford a strong initial test of whether the constellation of threat responses reflective of SIC function as risk factors or correlates of OCD symptoms.

Method

Participants

One hundred and thirty-eight first-semester college students were recruited from the University of Minnesota. Inclusion criteria were identical to the first two studies except thatparticipants needed to be first-semester university students between the ages of 18-19. Additionally, participants were required to have never lived away from their caregivers for three months or longer in an effort to ensure that the beginning of college was a relatively novel transition across participants. Of the 138 tested participants, 39 failed to

complete the symptom follow-up survey in the Spring semester, nine discontinued during the experiment, six had incomplete data resulting from the paradigm malfunctioning, and one participant was excluded for failing to acquire the CS+/US contingency (as indicated by a greater threat expectancy rating to the CS- relative to CS+). This left data available for 83 participants (58% female).

Questionnaires

In addition to the OCI-R, participants also completed the Generalized Anxiety Disorder Screener (GAD-7; Spitzer, Kroenke, Williams, & Lowe, 2006), the Liebowitz Social Anxiety Scale(Leibowitz, 1987), and the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). These questionnaires were used to assess whether task indices were specific prospective predictors of OCD symptoms or also predicted symptoms of other anxiety disorders (GAD-7, LSAS) and depression (BDI-II).

Experimental Paradigm

The experimental paradigm used in this study was identical to the version used in study 1(see Chapter 3, Section 3.2). The one difference was the only the 1-shock and 3-shock conditions were administered, aversion to which was rated immediately following the conclusion of the experiment.

Procedure

Participants first completed a lab visit during the Fall of their first semester, during which the PIG paradigm was administered in an identical fashion as is study one (see chapter 3, Section 3.2). Within two days of

their lab visit, participants were given an online survey in which they completed the OCI-R, GAD-7, LSAS, and BDI-II among other measures. Participants who completed both the lab visit and this survey were then contacted at approximately the same point during the following Spring semester and invited to complete a shortened version of the same online survey they were given at baseline in exchange for $10.

Data Analysis

Differences between stimuli during Preacquisition and Acquisition for each type of threat response (threat expectancy, anxiety, startle) were assessed with separate 3-level (Stimulus type: ΔCS-, CS-, CS+) rANOVAs. Differences between stimuli during the Test phase for each type of threat response (threat expectancy, anxiety ratings, startle, avoidance choices) were tested using separate 6-level (Trial type: ΔCS-, CS-, GS_1, GS_2, GS_3, CS+) by 2-level (US intensity: 1 shock vs. 3 shocks) rANOVAs. When appropriate, analyses were followed by paired samples *t*-tests.

Symptom changes across semesters. Paired-sample *t*-tests were conducted to compare levels of OCI-R, LSAS, GAD-7, and BDI-II scores between the Fall and Spring semesters. The mean score within each quartile for these measures is also reported for both timepoints to illustrate the range of symptom trajectories across participants.

Main analyses. To test concurrent relations between threat responses and OCD symptoms, separate hierarchical regression models for each response type (threat expectancy, anxiety, startle, avoidance choices) to improbable

threat (ΔCS-, CS-, GS_1) and more probable threat (GS_2, GS_3, CS+) were used to predict OCI-R scores at baseline (i.e., Fall semester). A specific response index (e.g., average threat expectancy improbable threat, average anxiety to more probable threat, etc.) was entered in the first step to assess the effect of responses to threats of different probabilities. The mean threat aversion ratings across the 1- and 3-shock conditions (i.e., average of participants' ratings of how important it was for them to not receive shock in the 1- and 3-shock conditions) was entered next to test the influence of participants' general aversiveness to the experimental threat. Finally, the Threat response x Threat aversion interaction was entered in the last step to assess whether responding to a particular probability grouping of experimental threat (e.g., improbable threat) was more predictive of OCD symptoms among individuals who were more averse to the threat's potential consequences (i.e. higher threat aversion ratings).

Next, these same responses were tested as predictors of future OCD symptoms. For these models, baseline OCI-R scores were entered in the first step to control for any differences in follow-up OCD symptoms that were present at baseline. The same set of predictors as the baseline models were entered next in the same order (i.e., threat response index, threat aversion ratings, Threat response x Threat aversion interaction).

For both sets of models (i.e., concurrent and future OCI-R scores), significant Threat response x Threat aversion interactions were followed up by testing the effect of the threat response variable among participants reporting

low aversion to threat (i.e., average threat rating < 7) and those reporting high aversion to threat (i.e., average threat rating ≥ 7). The groups were divided on this level of threat aversion rating on the basis of a median split.

Finally, to assess whether threat responses were more broadly predictive of anxiety and depression symptoms more generally, this identical data analytic plan was employed again for the three other symptom measures: GAD-7, LSAS, and BDI-II.

OCI-R subscale analyses. As in previous studies, significant effects with overall OCI-Rwere re-run replacing total OCI-R scores with scores on each of the six OCI-R subscales. Because no definitive pattern of results with subscales were gleaned in the previous two studies, no explicit hypotheses were made about which subscales would be predicted from indices of improbable threat responding. Significance was set at $p \leq .05$ for all statistical tests.

Results

Pre-acquisition

Prior to acquisition, small, statistically significant differences between stimuli (ΔCS-, CS-, CS+) were detected for both threat expectancy ratings $F(2, 80) = 3.93$, $p = .021$, and anxietyratings, $F(2, 80) = 3.41$, $p = .035$. These differences appeared driven by greater responding to ΔCS- (chance: M =29.48, SD = 21.10; anxiety: M =29.16, SD = 19.86) relative to CS- (chance: M =25.39, SD = 20.82; anxiety: M =26.53, SD = 18.90), for both threat expectancy ratings, $t(82) = 2.98$, $p = 0.004$, and anxiety ratings, $t(82) = 2.64$, $p = 0.016$. Responding to CS+ (chance: M =27.13, SD = 21.90; anxiety: M =27.93, SD = 19.44) did not

differ from ΔCS- in terms of threat expectancy ratings, $t(85) = 1.44$, $p = 0.15$, or anxiety ratings, $t(82) = 1.49$, $p = 0.14$, or from CS- in terms of threat expectancy ratings, $t(82) = -1.33$, $p = 0.19$, or anxiety ratings, $t(82) = -0.93$, $p = 0.36$. Therefore, no differences between the danger cue (CS+) and the safety cues (ΔCS-, oCS-) were detected prior to acquisition,

Acquisition

During acquisition, a main effect of stimulus type was found for threat expectancy ratings, $F(2, 80) = 222.734$, $p < .0001$, $\eta^2 = 0.72$, and reflected higher ratings to CS+ *(M*= 66.61, *SD* = 19.79) relative to CS- (*M* = 27.08, *SD* = 19.01), $t(82) = 16.59$, $p < .001$, and ΔCS- (*M* = 25.69, *SD* = 17.28), $t(82) = 15.10$, $p < .001$, which did not differ from each other, $t(82) = -1.11$, $p = .27$. A main effect of stimulus type was also found for anxiety ratings, $F(2, 80) = 89.37$, $p < .0001$, $\eta^2 = 0.51$, and reflected higher ratings to CS+ *(M*= 47.76, *SD* = 22.51) relative to CS- (*M*= 31.37, *SD* = 19.41), $t(82) = 10.41$, $p < .001$, and ΔCS- (*M* = 30.58, *SD* = 18.61), $t(82) = 9.80$ $p < .001$, which did not differ from each other, $t(82) = -1.10$, $p = .31$.

Test Phase

Threat expectancy. For threat expectancy, there was a main effect of stimulus typeduring the Test phase, $F(5, 77) = 390.16$, $p < .001$, $\eta^2 = 0.82$, which was driven by progressively lower threat expectancy ratings as stimuli became more dissimilar from CS+ (linear decrease: $F(1, 81) = 596.33$, $p < .001$, $\eta^2 = 0.88$; quadratic decrease: $F(1, 81) = 239.92$, $p < .001$, $\eta^2 = 0.78$). Pairwise

comparisons revealed that all stimuli from the improbable threat cluster (ΔCS-, CS-, GS_1) were a) rated as significantly less likely to result in shock compared tostimuli from the more probable threat cluster (GS_2, GS_3, CS+; *p*s < .001). In contrast to previousto investigations, threat expectancy to GS_1 was greater than CS-, $t(82) = 3.51$, $p = .001$, and ΔCS-, $t(82) = 2.35$, $p = .021$; threat expectancy did not differ between ΔCS- and CS-, $t(82) = 0.43$, $p = .67$. significantly differently in terms of shock risk from each other (*p*s > .15). However, the difference between GS_1 and GS_2 was markedly larger than the difference between GS_1 and oCS-/ΔCS-, indicating the improbable and more probable threat cluster groups utilized in the previous studies were appropriate for this study as well.

There was also a main effect of intensity level reflecting greater threat expectancy ratings during the 3-shock condition relative to the 1-shock condition, $F(1, 81) = 4.59$, $p = .035$, $\eta^{\$} = 0.051$, as well as a significant Intensity level x Stimulus type interaction, $F(5, 77) = 3.20$, $p = 008$, $\eta^{\$} = 0.036$. Follow-up analyses comparing threat expectancy ratings between shock conditions separately for each stimulus type revealed heightened expectancy of threat in the 3- shock relative to the 1-shock condition for GS_2, $t(82) = 3.27$, $p = .002$, and CS- at the level of atrend, $t(82) = 1.91$, $p = .059$, but not for any other stimulus type (*p*s > .22).

Anxiety ratings. For anxiety ratings, there was a main effect of stimulus type $F(5, 77) = 163.72$, $p < .001$, $\eta^{\$} = 0.66$, which was again driven by progressively lower anxiety ratings as stimuli became more dissimilar from

CS+ (linear decrease: $F(1, 81) = 213.62$, $p < .001$, $\eta^2 = 0.72$; quadratic decrease: $F(1, 81) = 117.72$ $p < .001$, $\eta^2 = 0.59$). Pairwise comparisons revealed that all stimuli from the improbable threat cluster evoked significantly less anxiety compared to stimuli from the more probable threat cluster (ps < .001), but did not differ from each other (ps > .21). There was also a main effect of intensity level reflecting greater anxiety ratings during the 3-shock condition relative to the 1-shock condition, $F(1, 81) = 8.62$, $p = .004$, $\eta^2 = 0.091$, as well as a significant intensity level x stimulus type interaction, $F(5, 77) = 2.41$, $p = .036$, $\eta^2 = 0.027$. Follow-up analyses comparing anxiety ratings between shock conditions for each stimulus type separately revealed that greater anxiety in the 3-shock condition relative to the 1-shock condition for GS_2, $t(82) = 3.26$, $p = .002$, CS+, $t(82) = 2.58$, $p = .011$, and CS- at the level of a trend, $t(82) = 1.91$, $p = .059$, but not for any other stimulus type (ps > .14).

Startle EMG. For startle, there was a main effect of stimulus type $F(5, 77) = 22.89$, $p < .001$, $\eta^2 = 0.24$, which was again driven by progressively lower startle as stimuli became more dissimilar from CS+ (linear decrease: $F(1, 81) = 47.08$, $p < .001$, $\eta^2 = 0.39$; quadratic decrease: $F(1, 82) = 10.81$, $p = .002$, $\eta^2 = 0.13$). Pairwise comparisons revealed that all stimuli from the improbable threat cluster evoked significantly less startle compared to stimuli from the more probable threat cluster (ps < .012), but did not differ from each other (ps > .83). There was also amain effect of intensity level reflecting greater startle during the 3-shock condition relative to the 1-shock condition, $F(1, 81) = 6.56$, $p =$

.012, η^2 = 0.081, but not a significant Intensity level x Stimulus type interaction, $F(5, 77) = 0.82$, $p = .47$, $\eta^2 = 0.012$.

Avoidance choices. For avoidance, there was a main effect of stimulus type $F(5, 77) = 90.78$, $p < .001$, $\eta^2 = 0.53$, which was again driven by progressively lower avoidance as stimuli became more dissimilar from CS+ (linear decrease: $F(1, 81) = 123.74$, $p < .001$, $\eta^2 = 0.60$; quadratic decrease: $F(1, 81) = 55.42$, $p < .001$, $\eta^2 = 0.40$). Pairwise comparisons revealed that all stimuli from the improbable threat cluster (ΔCS- , CS-, GS_1) were avoided less than all stimuli from the more probable threat cluster (*p*s < .001). Within the improbable threat cluster, GS_1 was avoided slightly more than CS-, $t(82) = 2.50$, $p = .014$, but no other pairwise differences were significant (*p*s > .08). There was also a main effect of intensity level, such that more avoidance choices occurred during the 3-shock condition compared to the 1-shock condition, $F(82, 1) = 10.35$, $p = .002$, $\eta^2 = .11$, as well as a significant intensity level x stimulus type interaction, $F(80, 5) = 2.40$, $p = .037$, $\eta^2 = .027$. Follow-up analyses comparing the percent of avoidance choices made between shock conditions for each stimulus type revealed a greater percentage of avoidance choices in in the 3-shock condition versus the 1-shock condition for GS_2, $t(82) = 2.08$, $p = .041$, GS_3, $t(82) = 3.17$, $p = .002$, and CS+, $t(85) = 2.31$, $p = .028$, but not any other stimulus type (*p*s > .30).

Symptom Changes across Semesters

Differences in symptoms measures (OCI-R, GAD-7, LSAS, BDI-II) from baseline to follow-up can be found below in Table 5.1. Although OCD symptoms decreased significantly from baseline to follow-up ($p < .01$), there was marked variability in change scores across quartiles, as demonstrate by large decreases from the first to second semester for quartiles one and two, no change in quartile three, and a large increase for quartile four. A marginally significant decrease in social anxiety symptoms was also observed from baseline to follow-up ($p = .072$), while symptoms of GAD did not differ from baseline to follow-up, and depression symptoms significantly increased ($p < .05$).

Table 5.1: Differences in symptom measures from baseline to follow-up.

Symptom Measure	Baseline Average (SD)	Follow-up Average (SD)	*t*-value	*Q*1 Change Mean (SD)	*Q*2 Change Mean (SD)	*Q*3 Change Mean (SD)	*Q*4 Change Mean (SD)
OCI-R	14.11 (12.29)	10.55 (9.37)	-2.70**	-18.33 (8.37)	-5.52 (1.56)	-0.30 (0.98)	11.29 (8.30)
GAD-7	5.68 (4.56)	5.80 (4.24)	0.22	-5.11 (3.42)	-0.52 (0.53)	1.80 (0.82)	6.88 (3.56)
LSAS	43.48 (24.64)	37.87 (24.99)	1.82^	-36.53 (10.94)	-14.16 (5.16)	0.52 (3.92)	32.04 (27.97)
BDI-II	9.91 (8.07)	12.10 (12.10)	2.48*	-5.71 (5.61)	0.042 (0.83)	4.57 (2.33)	14.00 (5.70)

Note. Symptom changes are defined as the symptom score at follow-up minus the symptom score at baseline. Q1 – Q4 change refers to the mean symptom change score in each quartile of the sample based on change score. OCI-R = Obsessive Compulsive Inventory – Revised. GAD-7 = Generalized Anxiety Disorder 7; LSAS = Leibowitz Social Anxiety Scale; BDI-II = Beck Depression Inventory – II; ^$p \leq .072$. * $p \leq .05$. **$p \leq .01$. $N = 83$.

Associations between threat responses and baseline OCD symptoms

OCI-R scores at baseline were not significantly associated with any index of threat responding to improbable or more probable threat (ps > .12), or by any Threat response x Threat aversion interactions ($p > .29$). Of note,

avoidance of improbable threat was associated with baseline OCI-R scores at the level of a trend, β = 0.21, $t(81) = 1.96$, $p = .054$.

Predicting Future OCD Symptoms from Threat Responses

Baseline OCI-R was entered in the first step in all models and emerged as a highly significant predictor, β = 0.41, $t(81) = 4.26$, $p < .001$, explaining 16.9% of the variance in future OCI-R scores, $F(1, 81) = 16.56$, $p < .001$.

Table 5.2 shows the effects of each threat response, threat aversion ratings, and each Threat response x Threat aversion interaction on future OCI-R scores. For improbable threat, future OCI-R scores were significantly predicted by higher threat expectancy, anxiety ratings, and avoidance choices. The effect of threat aversion was not significant across models, but the improbable threat response x threat aversion interaction was significant for anxiety, as well as forstartle at the level of a trend. In contrast, improbable threat avoidance x threat aversion interaction was not significant; however, the interaction term had a variance inflation factor (VIF) of 13.61, which is well-above the recommended threshold of four and was thus indicative of problematic levels of multicollinearity (Hair, Anderson, Babin, & Blac, 2010). Therefore, the Avoidance x Threat aversion interaction could not be readily interpreted. For more probable threat, no threat response or threat response x threat aversion interaction term was predictive of future OCI-R scores, although avoidance of more probable threat was significant at a trend-level ($p = .06$).

Table 5.2: Effects of Reactivity to improbable and more probable threat on future OCI-R scores

Threat Cluster	Step	Predictor	*F*	ΔR^2	β	*p*
Improbable threat	1	Threat Expectancy	6.59	.063	0.25	.013
	2	Threat Aversion	0.003	.000	0.006	.99
	3	Threat Expectancy x Threat Aversion	0.08	.001	0.04	.78
	1	Anxiety Ratings	6.21	.060	0.25	.015
	2	Threat Aversion	0.09	.000	0.010	.93
	3	Anxiety Rating x Threat Aversion	4.01	.038	0.20	.049
	1	Startle FPS	1.72	.019	0.14	.19
	2	Threat Aversion	1.12	.012	0.11	.29
	3	Startle x Threat Aversion	3.56	.038	0.20	.063
	1	Avoidance	11.91	.108	0.34	.001
	2	Threat Aversion	0.083	.000	-0.03	.77
	3	Avoidance x Threat Aversion	0.63	.006	-0.28	.43^
More probable threat	1	Threat Expectancy	0.74	.009	0.07	.39
	2	Threat Aversion	0.52	.005	0.08	.48
	3	Threat Expectancy x Threat Aversion	1.00	.012	0.14	.32
	1	Anxiety Ratings	2.63	.026	0.16	.11
	2	Threat Aversion	0.002	.000	0.005	.96
	3	Anxiety Rating x Threat Aversion	1.27	.013	0.12	.26
	1	Startle FPS	0.61	.007	0.08	.44
	2	Threat Aversion	0.82	.009	0.10	.37
	3	Startle x Threat Aversion	0.25	.003	-0.05	.62
	1	Avoidance	3.49	.035	0.19	.066
	2	Threat Aversion	0.90	.009	-0.16	.35
	3	Avoidance x Threat Aversion	0.065	.001	0.030	.80

Note. Beta weight reflect the effect of each threat response type on follow-up OCI-R scores controlling for baseline OCI-R scores. Improbable threat is defined as the average response to the three stimulus classes least similar to the conditioned danger cue (i.e., ΔCS-, CS-, GS_1) and more probable threat is defined as the average response to the three stimulus classes most similarto the conditioned danger cue (GS_2, GS_3, and CS+). Threat aversion is the average reported importance of not receiving shock during the 1- and 3-shock conditions. FPS = Fear-potentiated startle. OCI-R = Obsessive Compulsive Inventory – Revised. CS+ = Conditioned danger cue. GS_{1-3} = Generalization Stimulus 1 – 3; CS- = Circular safety cue. ΔCS- = triangular safety cue. *N* = 83. ^Predictor had a variance inflation factor of greater than 4 (13.61) so its effect should notbe interpreted.

Because the improbable threat response x threat aversion interaction was significant for anxiety ratings, marginally significant for startle, and not

interpretable for avoidance, the effect of each of these threat responses on future OCI-R scores was tested for those reporting low aversion to the threat (i.e., average threat aversion rating < 7) vs. those reporting high aversion to threat (i.e., average threat aversion rating ≥ 7) to better understand the influence of threat aversion. For comparative purposes, the effect of improbable threat expectancy within these groups was also tested, as was the effect of more probable threat responses.

As shown in Table 5.3, each type of response to improbable threat was a significant predictor of future OCD symptoms in the high threat aversion group except for startle (p = .13).In contrast, no improbable threat response was a significant predictor of future OCD symptoms in the low threat aversion group (ps > .24). For responses to more probable threat, only avoidance in the high threat aversion group emerged as a significant predictor, while startle in the low threat aversion group was significant at the level of a trend (p = .06)

Table 5.3: Effects of threat responses to improbable and more probable threat on future OCI-Rscores for the low threat aversion and high threat aversion groups

Threat Aversion Group	Predictor	*F*	ΔR^2	β	*p*
Low Threat Aversion	Improbable Threat Expectancy	1.38	.025	0.16	.25
	More Probable Threat Expectancy	0.12	.002	0.049	.73
	Improbable Threat Anxiety	0.07	.001	0.036	.80
	More Probable Threat Anxiety	0.44	.008	0.091	.51
	Improbable Threat Startle	0.000	.000	0.02	.99
	More Probable Threat Startle	3.62	.068	.28	.07
	Improbable Threat Avoidance	1.30	.024	0.16	.26
	More Probable Threat Avoidance	1.27	.023	0.16	.27
High Threat Aversion	Improbable Threat Expectancy	4.73	.097	0.31	.036
	More Probable Threat Expectancy	0.51	.012	0.11	.48
	Improbable Threat Anxiety	8.21	.156	0.40	.007
	More Probable Threat Anxiety	2.63	.057	0.24	.11
	Improbable Threat Startle	2.92	.067	0.26	.097
	More Probable Threat Startle	0.009	.000	-0.02	.93
	Improbable Threat Avoidance	10.03	.199	0.47	.002
	More Probable Threat Avoidance	4.42	.091	0.30	.042

Note. Threat aversion is the average reported importance of not receiving shock during the 1- and 3-shock conditions. The low aversion group (n = 43) and high aversion group (n = 40) had an average threat aversion rating of < 7 and ≥ 7, respectively. Beta weight reflect the effect of each threat response type on follow-up OCI-R scores controlling for baseline OCI-R scores. Low Improbable threat is defined as the average response to the three stimulus classes least similar to the conditioned danger cue (i.e., ΔCS-, CS-, GS_1) and more probable threat is defined as the average response to the three stimulus classes most similar to the conditioned danger cue (GS_2, GS_3, and CS+). OCI-R = Obsessive Compulsive Inventory – Revised. CS+ = Conditioned dangercue. GS_{1-3} = Generalization Stimulus 1 – 3; CS- = Circular safety cue. ΔCS- = triangular safety cue. $N = 83$.

Finally, to illustrate how OCD symptom trajectories differed as a function of both threat aversion and threat probability, the average OCI-R score at both time points was plotted for participants scoring in the upper and lower halves of each response variable for improbable threat separately for low and high threat aversion groups. Since over half the low threat aversion group never avoided any stimuli within the improbable threat group, improbable threat avoidance

within this group is instead split into those who avoided (n = 33) vs. those who never avoided (n = 9). These graphs can be found below in Figure 5.4 below.

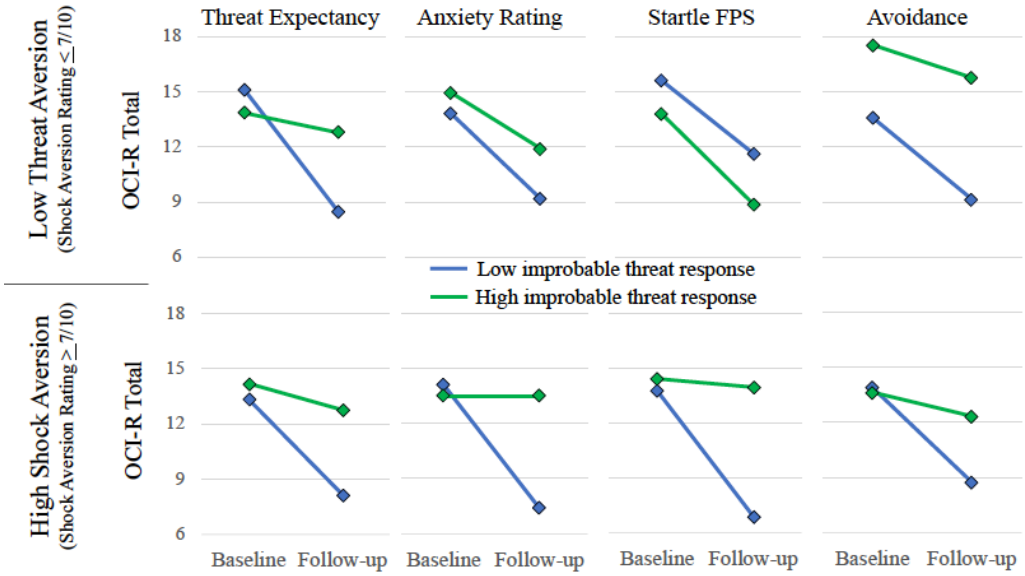


Figure 5.1. OCD symptom trajectories across participants group based on threat aversion ratings (top and bottom) and response sot improbable threat cues (green and blue lines). Baseline OCI-Rand task data were collected in participants' first semester of college and follow-up OCI-R were collected at the same point in participants' second semester. Improbable threat is the average response to the three stimulus classes least similar to the conditioned danger cue (i.e., ΔCS-, CS-,GS_1). Threat aversion is the average reported importance of not receiving shock during the 1- and 3-shock conditions. The low aversion group (n = 40) and high aversion group (n = 43) had an average threat aversion rating of < 7 and ≥ 7, respectively. Low and high response groups were based on median splits conducted within the threat aversion groups, except for improbable avoidance within the threat aversion group, which was split between those who avoided (n = 9) vs. those who never avoided (n = 33). FPS = Fear-potentiated startle. OCI-R = Obsessive Compulsive Inventory Revised. CS+ = Conditioned danger cue. GS_1 = Generalization Stimulus 1; CS- = Circular safety cue. ΔCS- = triangular safety cue. *N* = 83.

Predicting Future GAD, SAD, and Depression Symptoms from Threat Responses

Next, to assess whether the same types of threat responses emerged as predictors of symptoms for other anxiety disorders and depression, the identical data analytic plan was rerun substituting OCI-R scores for scores on the GAD-7

(GAD symptoms), LSAS (SAD symptoms),and BDI-II (depression symptoms). For SAD symptoms, trend-level effects were found for avoidance of improbable threat predicting higher LSAS scores at follow-up, β = 0.20, $t(81) = 1.96$, $p = .054$, but not for any other response type to improbable, more probable threat or their constituent interactions with threat aversion (ps > .11). For GAD symptoms, higher GAD-7 scores at follow-up were predicted at trend levels by both higher expectancy of improbable threats, β = 0.20, $t(81) = 1.83$, $p = .071$, and more probable threat, β = 0.20, $t(81) = 1.90$, $p = .061$, and greater anxiety of more probable threat, β = 0.19, $t(81) = 1.77$, $p = .083$, but no other response type to improbable threat, more probable threat, or their constituent interactions with threat aversion (ps > .12). Finally, for depression symptoms, the threat expectancy x threat aversion interaction for more probable threat emerged as a significant predictor, β = -0.19, $t(81) = -2.07$, $p = .042$, which explained 2.6% additional variance in future BDI-II scores, $F(77, 5) = 4.23$, $p = .042$. No other response type to improbable or more probable threat or their interactions with threat aversion emerged as significant predictors of future depression symptoms (ps > .10).Thus, the same responses to improbable and/or aversive threats that were predictive of OCD symptoms did not appear to be predictive of symptoms of other anxiety disorders or depression.

Predicting Future OCI-R Subscale Scores from Threat Responses

Finally, to understand whether threat responses and their interactions with threat aversionwere more strongly predictive of specific future OCD symptoms, the identical data analytic planwas re-run replacing overall OCI-R

with each OCI-R subscale. Results for these tests are shown below in Table 5.5. Expectancy for improbable threat was a significant predictor of future washing, checking, and ordering symptoms, as well as hoarding at the level of a trend (p = .085).Anxiety to improbable threat was a significant predictor of future washing and ordering symptoms, as well as hoarding symptoms at the level of a trend (p = .053) and checking at the level of a trend (p = .073). The Improbable threat anxiety x Threat aversion interaction was also asignificant predictor of future washing symptoms, and a trend-level predictor for checking (p = .098) and obsessing symptoms (p = .08). Startle to improbable threat was a significant predictor of future washing symptoms, and the startle to Improbable threat x Threat aversion interaction was a significant predictor of future obsessing symptoms. Avoidance of improbable threat was a significant predictor of future checking, washing, and ordering, and obsessing symptoms, as wellas hoarding symptoms at the level of a trend (p = .053). The Improbable threat avoidance x Threat aversion was a significant predictor of future obsessing symptoms, but it was in the negative direction, contrary to the expectations.

Table 5.4

Threat response	OCI-R Subscale (DV)	Predictor	F	ΔR^2	β	p
Threat Expectancy	Checking	Response	4.72	.052	0.23	.033
		Response x Aversion	0.001	.000	-0.006	.97

	Washing	Response	6.21	.051	0.23	.015
		Response x Aversion	1.86	.015	0.17	.18
	Ordering	Response	5.94	.061	0.25	.017
		Response x Aversion	0.062	.001	0.035	.80
	Neutralizing	Response	0.96	.011	0.11	.33
		Response x Aversion	0.49	.006	0.10	.49
	Obsessing	Response	2.23	.023	0.26	.14
		Response x Aversion	0.063	.001	0.035	.80
	Hoarding	Response	3.04	.033	0.18	.085
		Response x Aversion	0.83	.009	-0.13	.37
Anxiety Ratings	Checking	Response	3.31	.037	0.20	.073
		Response x Aversion	2.81	.031	0.19	.098
	Washing	Response	9.48	.076	0.28	.003
		Response x Aversion	5.68	.043	0.22	.020
	Ordering	Response	4.78	.050	0.23	.032
		Response x Aversion	0.91	.009	0.10	.34
	Neutralizing	Response	2.34	.027	0.16	.13
		Response x Aversion	1.76	.020	0.15	.19
	Obsessing	Response	0.57	.006	0.08	.45
		Response x Aversion	3.05	.031	0.18	.08
	Hoarding	Response	3.85	.041	0.20	.053
		Response x Aversion	0.89	.010	0.10	.35
Startle FPS	Checking	Response	0.28	.003	0.060	.60
		Response x Aversion	0.92	.012	0.10	.34
	Washing	Response	6.23	.055	0.24	.015
		Response x Aversion	0.76	.007	0.084	.39
	Ordering	Response	2.01	.023	0.15	.16
		Response x Aversion	2.22	.024	0.16	.14
	Neutralizing	Response	0.006	.000	0.008	.94
		Response x Aversion	1.41	.017	0.13	.24
	Obsessing	Response	0.061	.001	0.026	.81
		Response x Aversion	5.31	.057	0.24	.024
	Hoarding	Response	1.62	.019	0.14	.20
		Response x Aversion	1.79	.021	0.15	.19
Avoidance choices	Checking	Response	7.72	.083	0.28	.007
		Response x Aversion	1.72	.018	-0.50	.19
	Washing	Response	5.83	.048	0.23	.018
		Response x Aversion	0.95	.008	0.33	.33
	Ordering	Response	16.58	.152	0.40	<.001
		Response x Aversion	0.001	.000	-0.008	.98
	Neutralizing	Response	2.16	.025	0.16	.15
		Response x Aversion	0.002	.000	0.018	.97
	Obsessing	Response	5.23	.052	0.23	.025
		Response x Aversion	14.37	.118	-1.28	<.001
	Hoarding	Response	3.21	.034	0.19	.077
		Response x Aversion	1.05	.011	0.39	.31

Note. Beta values are the effect of each threat response on follow-up OCI-R subscales scores controlling for baseline levels of the same OCI-R subscale. Improbable threat is defined as theaverage response to the three stimulus classes least similar to the conditioned danger cue (i.e.,ΔCS-, CS-, GS_1). Aversion is the average reported importance of not receiving shock during the 1- and 3-shock conditions. Interactions between avoidance and threat aversion across all models had variance inflation factors > 4 and should therefore not be interpreted. OCI-R = Obsessive Compulsive Inventory – Revised. FPS = Fear-

potentiated startle. CS+ = Conditioned danger cue.GS_{1-3} = Generalization Stimulus 1 – 3; CS- = Circular safety cue. ΔCS- = triangular safety cue. *N* = 83.

Discussion

The purpose of this study was to evaluate whether heightened responsivity to improbable catastrophes acts as a correlate or risk factor of OCD symptoms. Results show that college students with higher expectancy, anxiety, and avoidance to improbable threats in their first semester exhibited greater OCD symptoms their second semester, consistent with heightened responsivity to improbable conferring increased risk for future OCD symptoms. Moreover, anxiety to improbable threat better predicted future OCD symptoms among individuals who weremore averse to threat, which was also true for startle at a trend-level, and evident for avoidance in follow-up tests involving threat aversion subgroups. This implies that threat responses to situations better approximating improbable catastrophes better discriminate those at elevated riskfor OCD. In contrast, no index of responding to more probable threat emerged as a significant predictor of future OCD symptoms, though avoidance emerge as a trend-level predictor. Accordingly, elevated risk for OCD symptoms appeared driven by a focal tendency to over- appraise and become distressed by improbable threats, especially when perceived as highly aversive, rather than a more general tendency to over-respond to all types of threats. Moreover, the same constellation of threat responses that predicted future OCD symptoms were not predictive of future symptoms of GAD, SAD, or depression, suggesting that heightened reactivity to improbable and highly

aversive threat acts as a relatively specific marker of susceptibility for OCD.

Interpreting Prospective Effects of Improbable Threat Responses

Results from the current investigation support the hypothesis that heightened responsivityto improbable threat acts a prospective marker of risk for OCD. Specifically, greater threat expectancy, anxiety, and avoidance of improbable threats, but not more probable threats, predicted a significant portion of the variance in second-semester OCD symptoms, even while concurrent (first semester) symptoms were controlled for. Accordingly, participants who experienced greater OCD symptoms at follow-up not only tended to overestimate improbable threats at baseline but were also more distressed and avoidant of them as well. These results addto the few prospective studies demonstrating the pathogenic role of dysfunctional beliefs in OCD(Abramowitz et al., 2006; Coles et al., 2008) by implicating a more specific tendency to maladaptively respond to improbable threat as a more focal vulnerability marker in the illness. Additionally, the fact that predictive effects were relatively specific to improbable threat, ratherthan more probable threat, adds further confidence to the notion that OCD is not marked by a more general tendency to overestimate threat (OCCWG, 2003).

While the centrality of improbable threat responding to OCD symptoms is consistent withfindings of the past two studies, there were some noteworthy inconsistencies when it came to results with specific threat indices. Most notably, OCD symptoms in the current study were significantly predicted by improbable threat anxiety, but not startle, while OCD symptoms in the first

study showed the opposite set of relations (i.e., OCD symptoms associated with startle but not anxiety to improbable threat). Regarding the null results involving startle, effects were in the predicted direction, making them at least partially consistent with earlier findings. Thus, as alluded to in the chapter 4, it is possible that failure to find consistent relations with startle may be attributable to startle simply not being as reliable as behavioral indices of threat responding(Bradford et al., 2015).

The discrepancy for anxiety ratings is more difficult to interpret. On one hand, it is a positive sign that OCD symptoms were predicted by improbable threat anxiety ratings in this study, as this response is arguably the most straightforward measure of threat reactivity in the paradigm. However, this finding is also inconsistent with the proposal in chapter 3 that the failure to find higher anxious reactivity to improbable threat among those higher on OCD symptoms reflects either a) that those higher on OCD respond to improbable catastrophes with a better-safe-than-sorry strategy, which occurs in the absence of anxiety, or b) that OCD-relevant anxiety is triggered only on choice trials that include an element of responsibility, and not on passive non-choice trials where anxiety ratings are collected. Because the experimental paradigmwas essentially identical in this study and the first study, it appears unlikely that null results involving anxiety in the first study were merely artefacts of task design, making both these explanations insufficient.

In lieu of these reasons, perhaps the most likely explanation for the relative inconsistencyof anxiety results is that this SIC is less likely to manifest

as conscious anxiety compared to other indicators of threat reactivity. Indeed, while 96% of OCD patients exhibit compulsions (i.e., avoidance), only 75% report reduction of anxiety or distress as a motivation behind their compulsive behavior (Starcevic et al., 2011). The DSM criteria for OCD also reflects the relativeinconstancy of subjective anxiety, stating only that obsessions *may* involve anxiety (APA, 2013).Thus, it could be the case that the PIG paradigm does a decent job of eliciting anxiety to improbable threats, but such responses are simply less common compared to threat-based manifestations like avoidance among those with elevated OCD symptoms.

Interpreting Interactions between Improbable Threat Responses and Threat Aversion in Predicting Future OCD Symptoms

Results partially supported the hypothesis that anxious reactivity to improbable threat would more robustly predict future OCD symptoms among those experiencing higher threat aversion. Specifically, anxiety ratings to improbable threat better predicted future OCD symptoms among those reporting greater levels of threat aversion, which was also the case for startle at a trend-level (p = .063). Moreover, even though the Improbable avoidance x Threat aversion interaction could not be interpreted due to an unacceptably high level of multicollinearity, avoidance of improbable threat was still a much stronger predictor of future OCD symptoms in the high threat aversion group compared to the low threat aversion group (which was also the case for anxiety and startle). Together, these findings suggest that anxiousreactivity to improbable threat is more useful for identifying those at

elevated risk for future OCD symptoms when collected under conditions involving greater threat aversion. In other words, risk for OCD may be best elucidated within the PIG paradigm when fear-related responses are assessed in conditions most closely resembling an improbable catastrophe.

Interestingly, similar effect patterns were not observed for threat expectancy, as the improbable threat expectancy x threat aversion interaction was interpretable (i.e., non- problematic multicollinearity) but did not approach significance (p = .78). This null result is consistent with the idea that the tendency to overestimate improbable threat is a more general bias that exists independent of the threat's aversiveness, which is supported by results in the firsttwo studies as well as in past experiments assessing threat estimates among OCD participants under conditions with low potential costs (Fear & Healy, 1997; Pélissier et al., 2002; Hermans et al., 2008). As such, the tendency to overestimate improbable threat likelihoods may serve as amarker of risk for OCD independent of subjective aversion to the particular outcome.

Interpreting Null Associations between Threat Responses and Baseline OCD Symptoms

The fact that OCD symptoms at baseline were not associated with improbable threat responses, including under conditions of higher threat aversion, is somewhat surprising since concurrent relations between these variables were found in both of the first two studies. One explanation for these null results is that the novel stress of the college environment elevated OCD symptoms among all participants regardless of whether they were sensitive to

improbable,threats or not, thereby thwarting associations between these threat responses and OCD symptoms. In other words, positive associations between baseline OCD symptoms and improbable threat responses may have been diluted by the fact that many participants had elevated OCD symptoms as a result of the transitionary stress of their first semester, and not because they possessed the underlying tendency to overrespond to these outcomes.

In support of this explanation, OCI-R scores in the full sample decreased significantly from semester one to semester two, which is suggestive of decreasing environmental stress and/or greater adjustment. Importantly, this decrease mirrors results from a larger longitudinal investigation of first year college students, in which psychological distress and anxiety spiked during participants' 1st semester, but increased much more mildly, decreased, or did not changeduring from their 1st to the 2nd semester (Conley, Kirsch, Dickson, & Bryant, 2014). Additionally, the experience of daily stressors among college students has been found to be a strong, concurrent predictor of OCI-R scores (Macatee, Capron, Schmidt, & Cougle, 2013) independent of other psychological variables (e.g., distress tolerance). Together, these findings suggest students likely experienced more stress in their first relative to second semester, that such stress could have increased OCD symptom, and that this non-specific stress-induced increase could have reduced the strength of the relationship between OCD symptoms and improbable threat responses at baseline. This account would also explain why concurrent relations were found between OCD symptoms and improbable

threat responses in the first two studies but not this study, as samples in these former investigations consisted largely of participants who were past their first semester of college. However, because associations between stressful experiences and threat responses were not explicitly tested in the current study, this explanation remains speculative at the current time.

Integrative Account of Prospective Relations between Threat Responses and OCDSymptoms

Taken together, the particular constellation of effects involving future OCD symptoms in this study suggests that those at heightened risk for OCD may be identified on the basis of two threat-response characteristics. First, those susceptible to OCD may express a specific tendency to overestimate the likelihood of improbable threats. This tendency appears to exist regardless of how aversive the individual perceives the threat to be, consistent with future OCD symptoms being predicted by higher expectancy of improbable threat, but not the Improbable threat expectancy x Threat aversion interaction. Additionally, there are a variety of OCD-relevant traits and biases that may result in the likelihood of improbable threats being overestimated (see Chapter 1, Section 1.5), which is suggestive of this overestimation being a stable characteristic inthe disorder.

Second, those at elevated risk for OCD may also demonstrate greater anxious reactivity toward improbable threats, but only when they are sufficiently averse to their potential consequences. For some, this heightened anxious reactivity to improbable threat may be elicited even if aversion to the

potential threat is quite low, perhaps as the result of being elevated on other, peripheral psychological factors that are both capable of exacerbating the experience of distress and have been linked to OCD (e.g., distress tolerance: Cougle, Timpano, Fitch, & Hawkins, 2011; intolerance of uncertainty: Tolin et al., 2003). Because of this, anxious responsivity to improbable threats may, on its own, distinguish individuals at increased risk forOCD—consistent with there being main effects of improbable threat anxiety and avoidance onfuture OCD symptoms.

For some individuals however, anxious reactivity to improbable threat is not apparent unless aversion to the threat is sufficiently high. In other words, some individuals that are at elevated risk for OCD symptoms may look indistinguishable from others if their fear responses to improbable threat are collected when aversion to threat is low, and thus require conditions involving more aversive outcomes for their latent proclivity to react anxiously toward improbable threat to become observable. This explains why anxiety, startle, and avoidance of improbable threat seemed to be better detectors of future OCD symptoms among individuals forwhom aversion to threat was *high*, as this subgroup included a greater proportion of participants whose latent proclivity to respond maladaptively to improbable threat had been revealed.

Implications of Prospective Relations between Improbable Threat Responses and OCDSymptoms

Although the presence of prospective, but not concurrent relations between improbable threat responses and OCD symptoms strongly suggests

that SIC is not merely a symptom of OCD, these results also cannot definitively implicate SIC as a causal vulnerability marker of the disorder. One major reason why this equivocation persists is that heightened reactivity to improbable, highly aversive threats mainly predicted the maintenance and/or decreased reduction of OCD symptoms, and not their development per se. Thus, it remains unclear whether SIC existed prior to the onset of the acutely stressful first semester period, thereby acting as a risk factor for future OCD symptoms, or was itself triggered by this transition, thereby functioning asa maintenance factor that predicts chronicity of previously developed OCD symptoms (Zvolensky et al., 2006). Moreover, even if SIC had temporally preceded and predicted the development of OCD symptoms, this would still not be enough to definitively implicate the sensitivity as a causal risk factor of OCD. Specifically, SIC could instead act as a *proxy risk factor* that predicts increased risk of OCD symptoms because it correlates with a third variable that itself is causally implicated in this disorder (Kraemer et al., 1997).

Although establishing SIC as a bonified vulnerability marker is an important endeavor, this sensitivity could still be clinically useful as a maintenance factor. In particular, results from this study highlight the utility of SIC for helping distinguish between individuals with transientlyelevated OCD symptoms versus those who may have developed a more chronic problem. Moreover, although the sample size and time course of this study are relatively small, the observed effect sizes are encouraging when it comes to the possibility of employing SIC-related measures in a clinical context. For

instance, among participants who were highly averse to shock, the proportion of variance in future OCD symptoms explained by anxiety and by avoidance of improbable threat was *greater* than what was explained by OCD symptoms at baseline. In other words, improbable threat responses among individuals with high threat aversion were even more useful in detecting future levels of OCD symptoms than the person's current level of OCD symptomology. Additionally, it is encouraging that this degree of prediction was achieved with measures of behavioral (anxiety, avoidance), rather than psychophysiological (startle EMG) indices of threat responding, as the former's more practical implementation provide a relatively more feasible pathway to clinical translation (Leneart et al.,2014).

Predicting Future Specific OCD Symptoms from Threat Responses

Overall, prospective relations between threat responses and future OCD symptoms were fairly consistent with what had been observed in the first study. Specifically, the most consistent effects were observed for washing, which was predicted by improbable threat reactivity for all four response types, and checking and ordering symptoms, which were predicted by all threat responses variables except for startle. Moreover, the interaction between improbable threat anxiety and threat aversion was strongest for washing and checking, which is reminiscent of these symptoms alone predicting heightened threat responding to improbable, highly aversive threats in study one. The relative consistency of effects involving washing, checking, and ordering symptoms might imply these OCD manifestations are simply more robustly

tied to SIC; however, the strength of their effects in the current study might also derive from them being particularly relevant to stressors associated with the collegiate environment. For instance, being exposed to a wider array of communicable diseases may be a particularly relevant trigger for washing symptoms, having to keep valuable possessions in shared spaces may be a particularly relevant trigger for checking symptoms, and having to live with a messy or unorganized roommate may be a particularly relevant trigger for ordering symptoms. Additionally, it bears noting that Washing, Checking, and Ordering tend to have some of the best psychometric properties among the OCI-R subscales, suggesting that found effects for these symptoms could partially reflect the fact that they are measured more reliably (Foa et al., 2002; Hajcak et al., 2004)

Conclusions

The current study examined whether a sensitivity to improbable catastrophes represents acorrelate or risk marker of OCD symptoms by testing concurrent and prospective relations between these variables across the first year of college. Results showed that individuals with higher threat expectancy, anxiety, and avoidance to improbable threats at baseline exhibited greater OCD symptoms at follow-up, while predictive effects involving anxious reactivity to improbable threats (subjective anxiety, startle, and avoidance) were stronger among participants who found threats more aversive. These findings are consistent with improbable threat reactivity acting as a vulnerability marker of OCD and suggest that susceptibility for OCD is most fully revealed when threat responses are collected in conditions approximating improbable

catastrophes. These results offer preliminary evidence that SIC could serve as a useful marker ofrisk for OCD and may be particularly helpful in discriminating between individuals with transient versus chronic symptoms of the illness.

Chapter 6: Conclusions, Implications, and Future Directions

The overarching purpose of this dissertation was to evaluate three claims related to the relationship of improbable catastrophes to OCD: 1) That OCD involves a heightened sensitivity to improbable catastrophes (SIC), 2) that SIC is driven by a tendency to overestimate the likelihood of improbable threats, and 3) that SIC and its associated processes are specific to OCDrather than general to anxiety pathology. In this final chapter, I will revisit each of these claims in light of the results of the three preceding studies, reviewing how well they were supported andhighlighting their remaining limitations. I will also present a preliminary model for how SIC could lead to the development of OCD symptoms and attempt to integrate the claims of this model with those outlined in OCD's major etiological theories. Finally, I will conclude the chapter by offering some preliminary suggestions for how a sensitivity to improbable catastrophes could ultimately be used to improve the assessment and treatment of OCD.

Question 1: Does OCD Involve a Heightened Sensitivity to Improbable Catastrophes?

In the current studies, the claim that OCD involves a heightened sensitivity to improbablecatastrophes was evaluated by examining whether participants reporting greater OCD symptoms exhibited higher anxious reactivity (anxiety ratings, startle, avoidance) to improbable threats thatwere also appraised as highly aversive. Because the experimental threat—electric shock—does not any direct relevance to OCD, any elevations in reactivity to

improbable, highly aversive threats among those with increased OCD symptoms likely reflect a more general sensitivity to improbable, highly aversive outcomes rather than a circumscribed aversion to electric shock. Similarly, the OCD assessment tool (i.e., the OCI-R; Foa et al., 2002), does not pertain to consequences or even subtypes with particularly strong theoretical relevance to improbable,catastrophic threats, but rather assesses more general kinds of OCD symptoms (e.g., "I frequently get nasty thoughts and have difficulty in getting rid of them). As such, links betweenand improbable, highly averse threat responses found in the current studies may be more readily attributable to general OCD pathology as opposed to clinical subgroups who are particularly sensitive to improbable catastrophes.

Overall, evidence that OCD is marked by a heightened sensitivity to improbable catastrophes was mixed. On one hand, results involving avoidance were quite robust: In each study, participants with higher OCD symptoms (whether measured concurrently or at a follow- up timepoint) were more likely to avoid the possibility of electric shock when it was both very unlikely (i.e., the stimulus was highly discrepant from the cue linked to electric shock) and very costly (i.e., the participant reported greater aversion to receiving electric shock). The consistency of this result is particularly noteworthy given that it was found in three different version of the experiment. These so-called "conceptual replications"—tests of the same question with different experimental parameters—often fail to replicate (Simons, 2014), suggesting that the strength of the relationship between OCD symptoms and avoidance of

improbable highly aversive threats was strong enough to overcome these methodological discrepancies.

In contrast, findings with indices of *passive* anxious reactivity (startle, anxiety) were lessconsistent. On one hand, heightened anxiety to improbable threat in the third study predicted greater OCD symptoms at follow-up among those who reported greater threat aversion—a resultthat was also marginally significant for startle. However, greater threat aversion did not facilitatea stronger relationship between OCI-R scores and increased anxiety or startle to improbable threats in either of the first two studies. This finding was both inconsistent with avoidance resultsand with the hypothesis that OCD symptoms confers increased anxious reactivity to improbable catastrophes across threat responses.

As discussed in chapter five, the discrepancy between passive and active responses is unlikely to be an artefact of the task. Specifically, any task-related reasons that might have contributed to null results for passive responses in one study should have applied in all of them. This leaves the possibility that SIC is actually more likely to manifest as avoidance as opposed toanxiety in OCD, which is supported by the relative frequency of these two symptoms in the disorder: While virtually all OCD patients engage in some sort of compulsive avoidance behavior (Foa & Kozak, 1995), only some are motivated by anxiety as opposed to other reasons (e.g., disgust reduction, achieving 'just-not-rightness', undoing the effect of obsessions; Starcevic et al., 2011). Thus, while behavioral (or perhaps mental) efforts to avoid improbable catastrophes

may be relatively constant across OCD patients, anxious apprehension of such events may be comparatively inconstant.

Of note, the relative strength of results involving active versus passive threat responses isalso consistent with more recent conceptualizations of OCD. Specifically, while etiological models of OCD have traditionally ascribed a more important role for obsessions in the pathogenesis of the illness, Gillan and colleagues have suggested that compulsive avoidance habits may actually develop prior to obsessional fears (Gillan et al., 2011; Gillan et al., 2014), which are merely post-hoc justifications for compulsive behavior (Gillan & Shakian, 2015). In the current studies, excessive habit formation may have contributed to avoidance arising earlier in the experiment relative to anxiety, which in turn would have made the former elevated to a greater degree among those with higher OCD symptoms when all trials across the experiment were averaged. Examining how OCD symptoms predicted changes in anxiety and avoidance throughout the PIG paradigm could be useful for validating this account and garnering further support for Gillan's habit hypothesis more broadly.

Differences between OCI-R subscales

In addition to examining effects with overall OCI-R, exploratory tests with individual OCI-R subscales were conducted to assess whether certain OCD symptoms predicted heightenedreactivity to improbable, highly aversive threats. Overall, results at the subscale level were less consistent compared to results with the overall OCI-R, making it difficult to identify a clear and

interpretable pattern. Indeed, the only subscales that showed any consistency were Washing and Checking. In the first study, Washing and Checking were the only OCI-R subscales that interacted positively with threat aversion in predicting avoidance of improbable threats. In study two, Washing and Checking again interacted with threat aversion in predicting avoidance of improbable threat, which was also true for Obsessing and Hoarding. Finally, in study three, Washing interacted positively with threat aversion in predicting anxiety ratings, as did Checkingat the level of a trend; Obsessing was the only other subscale approached significance.

There are at least two reasons for why results with Washing and Checking yielded the most consistent results. First, among the OCI-R subscales, Washing and Checking have the clearest theoretical links to OCD subtypes involving improbable catastrophes. Specifically, washing compulsions are often prompted by fears of contracting deadly diseases through improbable or even magical means (e.g., contracting HIV from a doorknob), while the checking-related items of the OCI-R relate to household security measures often enacted to prevent unlikely household disasters (e.g., checking locks to prevent burglaries, stoves to prevent fires, water taps to prevent floods). In contrast, other OCI-R subscales involve more general OCD symptoms (e.g., “I frequently get nasty thoughts and have trouble getting rid of them”) that could theoretically be elevated regardless of an underlying concern with improbable catastrophes. Thus, even though the Washing and Checking subscales do not explicitly mention improbable catastrophes, participants who were afraid of

improbable catastrophes might have been morelikely to endorse items on these subscales.

The second reason for the strength of results with the Washing and Checking subscales isthat these symptoms offered the best ecological match to the behavioral avoidance assessed in the task (see Chapter 3, Section 3.4). Specifically, these subscales both involve taking discrete physical actions to avoid potential threats, while other OCI-R subscales like Neutralizing involve responses that more closely mirror mental or covert acts that OCD patients utilize for neutralization purposes (e.g., “I feel I have to repeat certain numbers”). Further evidence supporting the importance of an ecological match for subscale effects comes from the Hoarding and Obsessing subscales. For instance, even though the Hoarding is considered a separate diagnostic entity from OCD, its subscale also involves behavioral responses (e.g., “I avoid throwing things away because I’m afraid I might need them later”), perhaps explaining why it was among the only subscales to interact positively with threat aversion in predicting improbablethreat avoidance for study two. Similarly, the Obsessing subscale, which arguably best approximate the tendency to become distressed or anxious (e.g., “I am upset by unpleasant thoughts that came into my mind against my will”), was among the only subscales to be predicted by a marginally significant interaction between improbable threat anxiety and threat aversion in study three. However, results with these two subscales were less consistent, making itdifficult to confidently interpret the presence versus absence of their effects in specific studies.

Limitations and Future Directions

Although findings from this dissertation offer strong preliminary evidence of links between OCD and heightened sensitivity to improbable catastrophe, there are at least two majorlimitations in the current work that should be addressed in future research.

First, results from all studies were generated using non-clinical samples. More specifically, even though a fairly significant proportion of each study's sample scored at or above the recommended clinical cut-off at which OCD is likely, the percent of each sample meeting diagnostic criteria for OCD is unclear. Because empirical models of OCD symptoms—including those using data from the OCI-R—suggest that OCD pathology is dimensional rather than categorical in nature (Olatunji et al., 2008), I do not believe this limitation necessarily affects the ability to infer that SIC is linked to the broader continuum of OCD pathology.

Nonetheless, replicating the current study with clinical OCD participants would be useful for understanding how this sensitivity extends to more severe levels of OCD pathology. For instance, even though OCD symptoms did not consistently predict passive levels of reactivity to improbable, highly aversive threats, this relationship might still be present among individuals with more severe OCD. Moreover, because OCD patients are by definition experiencing clinical significant distress or impairment, studying their reactions to threat within the PIG paradigm would be instrumental for linking SIC to OCD-related disruptions in daily living.

A second limitation when it comes to establishing links between OCD and SIC is that effects with specific OCD subtypes were not tested. A major tenet of the improbable catastrophe theory is that SIC is a generalized feature of OCD that applies across the disorder's major subtypes. Thus, it will be necessary to test how patients with different primary obsessions respond to the same non-OCD-relevant improbable catastrophe, as this will allow SIC to be moreconfidently implicated as a unifying sensitivity that unites these disparate forms OCD together.

In addition, replicating the current studies in a heterogeneous sample of OCD presentations could also help clarify the etiological role of SIC in OCD. For instance, it would be intriguing to examine whether levels of responding to improbable catastrophes in the task correlate with the number or severity of improbable, catastrophic fears reported by the OCD patient. Such work would be useful for understanding whether phenomenological differences in obsessions pertaining to improbable, catastrophes are indeed reflective of a greater sensitivity to these types of consequences.

Question 2: Is the Sensitivity to Improbable Catastrophes Driven by an Overestimation ofImprobable Event Likelihood?

The second claim in this dissertation was evaluated by examining whether purported links between OCD and SIC were coincident with a tendency to overestimate improbable threat likelihood. Overall, support for this claim was quite strong, as OCD symptoms predicted heightened expectancy of improbable threat (but not more probable threat) in each of the three studies.

Moreover, the same point about conceptual replicability used to illustrate the strength of the avoidance findings arguably applies even more aptly to threat expectancy. Specifically, significant findings with threat expectancy were not only obtained using different versions of the experiment, but the changes that were made to the experiments are those that should theoreticallyhave influenced results this threat outcome the most. This point is particularly applicable when considering the consistency of the threat expectancy results in studies one and two: These investigations assessed threat expectancy using different prompts (i.e., “Chance of shock?” vs. “Level of risk?”) and different scales (i.e., 10-point scale using percentage markers vs. 3-point Likert with ‘none’ ‘some’, and ‘a lot’ as markers), but yielded virtually identical findings when itcame to the effect size of OCI-R scores on these outcomes. Furthermore, OCD symptoms also predicted heightened threat expectancy to improbable harm- and disgust-related threats, further underscoring the robustness of the relationship between OCD and improbable threat overestimation.

Improbable threat overestimation as a manifestation of doubt

Although I did not test processes mediating relations between OCD and improbable threat expectancy, there are three features of the present findings that implicate excessive doubt as the underlying psychological process contributing to such effects.

First, heightened estimates of improbable threat for those with elevated OCD symptoms did not extend to more probable threats in any of the three

studies. This suggests that OCD is characterized by a specific tendency to overestimate improbable events, rather than a more global proclivity to overestimates all types of aversive outcomes (OCCWG, 2003). Second, elevations that did occur for improbable threat were relatively slight: In both study one and studytwo, a +1 *SD* increase in OCD symptoms was only associated with a 5-10% increase in rated likelihood for improbable threat above the average 5% rating of the sample. These slight overestimations of improbable threat likelihood are arguably consistent with an increased proclivity to doubt, which should putatively surface as an inability to *rule out* an improbable event, resulting in an estimated likelihood just above zero. Finally, these slight and specific overestimations of improbable threat likelihood among those with elevated OCD symptoms occurred independent of threat aversion, suggesting they occurred regardless of how averse the individual was to the potential threat. This finding is consistent with past studies showing that OCD patients manifest doubt even in situation with mildly aversive consequences (Hermans et al., 2008) or no consequences at all (Fear & Healy, 1997; Pélissier et al., 2002).

Interestingly, OCD symptoms often also predicted heightened anxious reactivity (startle,anxiety, avoidance) to improbable threats independent of threat aversion. Specifically, associations between OCD symptoms and improbable threat avoidance were found in all three studies, as were associations with startle in study one and anxiety in study three. Furthermore, in all cases except for those involving startle in study one, these associations

were clarified by an interaction involving threat aversion, such that associations between OCD symptoms and the index of improbable threat responding were stronger among participants who were more averse to threat. Thus, in contrast to results with threat expectancy, links between anxious reactivity to improbable threat and OCD symptoms were not *fully* independent of threat aversion.

One explanation for these findings is that individuals with elevated OCD symptoms havedifferent thresholds for whether they become anxious or avoidant to improbable threats. In other words, while those with elevated OCD symptoms might share a latent proclivity to doubt the non-occurrence of improbable threats, they may differ in how bothered they are by the possibility that such threat could occur. This would mean that at least some individuals with low thresholds for threat-related distress display anxiety and avoidance at low levels of threat aversion, thereby allowing simple two-way interactions between improbable threat anxiety/avoidance and OCD symptoms to surface. However, as threat aversion increases, individuals with elevated OCD symptoms and higher threat-distress thresholds may also begin to display anxious reactivity toward improbable threats, consistent with the relationship between improbable threat reactivity and OCD symptoms strengthening at higher levels of threat aversion. Though speculative, the notion of different threat-distress thresholds could explain whysome debilitating OCD-relevant fears involve less objectively severe consequences (e.g., yelling profanities in church: Abramowitz, 2006; believing one is ugly: Phillips, 2006), which could

arise from individuals possessing lower threat-distress thresholds for particular, less severe outcomes.

Overestimation of threat severity

An additional possibility for why improbable catastrophe arise commonly in OCD is that those with the disorder overestimate the severity of catastrophic consequences. Studies one and two evaluated this hypothesis by testing whether OCD symptoms and threat aversion interacted to predict greater anxious reactivity, consistent with those elevated on OCD symptoms exhibiting greater anxiety and avoidance of events that are more subjectively aversive. However, neither of these interactions approached significance, indicating that OCD symptoms did not confer any *additional* anxious reactivity to highly aversive threats relative to the increase in reactivity associated with higher threat aversion across all participants.

That OCD symptoms were associated with overestimating the likelihood of improbable threats, but not with anxious reactivity to highly aversive ones, is consistent with both past empirical evidence and with the theoretical properties of improbable catastrophes (see Chapter 1,Section 1.5). Empirically, evidence that OCD involves an overestimation of threat severity is much less robust than evidence for overestimated threat probability, as this association has been identified in some studies (Jones & Menzies, 1997; Woods et al. 2003; Moritz & Jelinek, 2009) but not others (Hinds, Woody, Van Ameringen, Schmidt, & Szechtman, 2012; Niemeyer et al., 2013; Zetsche et al., 2015). From a theoretical perspective, the objectively disastrous nature of

improbable catastrophes may render it difficult for any degree of inflated cost perception to swayone's appraisal of these events' overall aversive value (Salkovsks, 1996). For instance, if one (incorrectly) appraises contracting HIV from a doorknob as possible, it is hard to imagine that individual differences in the perceived cost contracting HIV would hold much sway over the decision to avoid the doorknob, as contracting HIV is an objectively awful consequence for all individuals. Thus, findings from the current studies are fairly consistent with past research and theory in demonstrating that the purported sensitivity to improbable catastrophes in OCD arises through a slight, perhaps doubt-mediated overestimation of improbable threat likelihoods, asopposed to an overestimation of costs associated with catastrophic outcomes.

Differences between OCI-R subscales

In contrast to findings with other outcomes, positive associations between specific OCI-Rsubscales and elevated ratings of improbable threat expectancy were more widely distributed. To help compare the consistency of these effects, I assigned each OCI-R subscale a point value based on the significance of its association with improbable threat likelihood ratings in each of the four tests that evaluated this relationship: The OCI-R subscale x stimulus interaction in predicting threat likelihood in study one, the main effect of each OCI-R subscale in predicting risk ratings to improbable shock in study two, the main effect of each OCI-R subscale in predicting risk ratings to the improbable disgust-related threat in study two, and the main effect of improbable threat expectancy ratings on predicting future levels of each OCI-R subscale in study

three. Totals consistency ratings for each OCI-R subscale can be found below in Table 6.1.

Table 6.1: Summary of significant OCI-R subscale relations with improbable threat expectancy

Test	Washing	Checking	Ordering	Neutralizing	Obsessing	Hoarding
Study 1	0	4	4	4	1	0
Study 2 Shock	2	2	2	2	3	2
Study 2 Disgust	1	3	0	0	0	0
Study 3	2	2	2	0	0	1
Total	5	11	8	6	6	3

Note. OCI-R subscales were assigned a numeric value for each test based on the significance value: 0 (no significance; $p > .10$), 1 (marginal significance; $p < .10$), 2 ($p < .05$; significance), 3 (high significance; $p < .01$), or 4 (very high significance; $p < .001$). The tests were the (negative) OCI-R subscale x stimulus interaction in predicting threat expectancy ratings in studyone; the OCI-R subscale main effect on improbable threat risk ratings for shock in study two; theOCI-R subscale main effect on improbable threat risk ratings for disgust in study two; and the effect of improbable threat expectancy ratings on future OCI-R subscales scores in study three. OCI-R = Obsessive Compulsive Inventory Revised.

According to this point system, most OCI-R subscales showed fairly consistency threat expectancy effects relative to each other, with two notable exceptions. First, effects involving the Hoarding subscale appeared to be the least consistent across the three studies. Hoarding is believed to possess a partially distinct etiology compared to OCD (Maier et al., 2004; Bloch et al., 2014), and as of DSM-5 is considered a separate diagnosis (APA, 2013). This etiological distinction is fully consistent with hoarding being the OCI-R subscale least consistently associated with overestimating improbable threat likelihoods, as this tendency is proposed as thekey abnormality behind the sensitivity (i.e., SIC) that putatively distinguishes OCD from other related conditions. Of course, hoarding-related behaviors are often made on the basis

of avoiding very low probability consequences (e.g., keeping a seemingly useless object on the belief that it may have utility in the future), making it sensible that links between hoarding symptoms and heightened improbable threat appraisals were at least partially supported.

On the other hand, checking-related symptoms showed by far the *most* consistent relations with elevations in improbable threat likelihood. This pattern is intriguing given that checking is arguably the OCD symptom that has been most robustly linked to the proclivity to doubt in past studies. For instance, Samuels et al. (2017) found that while levels of self-reporteddoubt were associated with most OCD symptoms, its relationship to checking was by far the strongest. In further support, checking has also exhibited the most consistent associations with doubt-related measures in experimental studies (e.g., Macdonald et al., 1997; Hermans et al., 2003; Hermans et al., 2008). Thus, it could be that the proclivity to doubt which underlies OCD most potently triggers checking-related symptoms, which is consistent with this symptom being among the most common manifestations of the disorder (Rasmussen & Eisen, 1992; Foa & Kozak, 1995).

Alternatively, links between checking and doubt could be partly an artefact of how doubt has been defined or manipulated in both the current studies and previous ones. Past studies that have found links between doubt and checking have involved procedures or questions that couchthe construct around reduced confidence for memory. For instance, experimental studies typically assessed doubt via self-report ratings of whether one has performed

or remembered some past action or experience accurately (Constans et al., 1995; Macdonald et al., 1997; Tolin et al., 2001; Hermans et al., 2003; Cougle et al., 2007). This is also true of the lone correlational study of doubt by Samuels et al. (2017), who assessed the construct with the single question "After you have completed a task, do you doubt whether you have performed it correctly?". Similarly, although doubt was not explicitly assessed in the current studies, reduced memory confidence is a likely candidate mechanism through which doubt could have exerted its influence, in particular uncertainty in recalling whether an improbable threat stimulus had previously coincided with shock. The relevance of reduced memory confidence to this study and past investigations may help explain the robustness of effects involving checking, which is arguably the manifestation of doubt that is most relevant to this symptom type. For instance, most prototypical examples of checking occur following repeated attempts to remember whether one performed some important household security-related task (e.g., locking the door, turning of the stove, shutting off the water, etc.). Accordingly, it is possible that using an experimental manipulation capable of eliciting *different* manifestations of doubt (e.g., doubt about whether oneis an evil or immoral person) could allow the construct to show stronger relationships with different kinds of OCD symptoms (e.g., religious or aggressive obsessions).

Limitations and Future Directions

There are two major limitations of the current work when it comes to establishing the primacy of probability-based distortions relative to cost-

based distortions in the genesis of SIC. First, although evidence favors a strong relationship between expectancy of improbable threat and OCD, the current studies were not designed to mechanistically link this tendency to SIC. Specifically, passive indices of threat responding (including threat expectancy) and active indices (i.e., avoidance) were assessed on separate, alternating trials, so I could not directly test whether overestimating the likelihood of improbable threat *caused* avoidance of such threats when paired with higher subjective costs. Indeed, it is possible that the reverse happened: Avoidance fostered increased estimations of improbable threat likelihood, which is consistent with Gillan and Shakian's (2015) proposal that threat-related beliefs (in the form of obsessions) are post-hoc justification for compulsive avoidance. As a middle ground, there could also be an interplay between avoidance and expectancy of improbable threat, wherein a (perhaps) doubt-mediated expectancy increase produces an initial avoidance behavior, which in turn insulates such expectancy beliefs from being disconfirmed. Future studies utilizing an experimental paradigm in which threat expectancy is collected immediately prior to avoidance choices could help clarifythe temporal relationship between these variables, as could more advanced statistical techniques like modeling of avoidance and threat probability ratings on a trial-by-trial basis.

Second, as alluded to earlier in this section, constructs mediating links between OCD symptoms and improbable threat expectancy effects were not measured. Thus, it cannot be definitively concluded that found associations

between improbable threat expectancy and OCD are mediated by doubt as opposed to a different process. Clarifying the contribution of doubt to this relationship could be done in two ways. First, the PIG paradigm could be amended to include more pointed questions about the degree to which doubt influenced one's behavior in thetask. For instance, participants could rate the degree to which they doubted whether stimuli fromthe improbable threat cluster were predictive of shock, or how confident they were that they accurately understood the rules of the task. This method is similar to what has been adopted in past studies (Constans et al., 1995; Macdonald et al., 1997; Tolin et al., 2001; Hermans et al.,2003; Cougle et al., 2007), and has proven useful for clarifying whether behavior within a paradigm is attributable to a doubt-related process.

A second option is to examine whether links between OCD symptoms and estimates of improbable threat likelihood are mediated by doubt-related proclivities in the real-world. This type of investigation would be an especially useful step for verifying that the propose doubt- induced sensitivity to improbable catastrophes is relevant to OCD in everyday life. However, the only study to my knowledge that has attempted to evaluate real-world doubt-related tendencies was Samuels et al. (2017), who assessed such proclivities with a single item. Thus, the lack of validated measures of doubt is a more global hindrance for OCD research that will need to be rectified before this particular limitation can be addressed.

Question 3: Is the Sensitivity to Improbable Catastrophes Specific to OCD?

The final claim about SIC in these studies is that the process is a specific feature of OCD and not a more general feature of anxiety pathology. The specificity of SIC can be inferred from phenomenological differences between OCD and similar anxiety-related conditions, whose prototypical feared consequences tend to be more probable, less catastrophic, or both (see Chapter 1, Section 1.3). Moreover, while many threat-related distortions are shared across OCD and other anxiety disorders (e.g., Tolin et al., 2003), traits thought to produce the elevations in improbable threat likelihood deemed central to SIC (e.g., reduced confidence in cognitive abilities: Hermans et al., 2008; inferential confusion: Aardema et al., 2005; magical ideation: Einstein & Menzies, 2006) tend to be more specific to OCD.

In the current studies, evidence for the specificity of SIC to OCD was assessed by testing whether significant effects with OCI-R scores remained significant when a) controlling for broader anxiety-related personality factors (studies one and two) and b) whether longitudinal associations with improbable, highly aversive threat responses generalized to other types of anxiety symptoms (study three). Overall, no tests supported the notion that SIC, or the elevation in improbable threat likelihood putatively contributing to it, is a general feature of anxiety pathology. In study one, all positive effects with OCI-R (i.e., higher expectancy, startle, and avoidance to more improbable threats; higher avoidance to threat appraised as more aversive) remained unchanged when shared variance with trait anxiety was partitioned out. This was essentially the same finding in study two, where all found effects with

OCI-R (higher risk ratingsand avoidance to improbable threat; higher avoidance of improbable threat rated as more aversive) remained significant despite levels of trait anxiety being controlled for. In study three, all the indices of improbable threat responding that significantly predicted changes in OCI-R scores (expectancy, anxiety, avoidance) failed to significantly predict changes in GAD or SAD symptoms. This specificity for predicting OCD symptoms also persisted when improbable threat rresponses were considered in conjunction with increased levels of threat aversion.

Limitations and Future Directions

Although the above tests provide fairly strong evidence that SIC is not a general feature of anxiety pathology, they cannot definitively rule out the role of this sensitivity in specific anxiety disorders. Specifically, it could be the case that SIC, or an increased proclivity to doubt, applies to other types of disorders which may also involve fears of improbable, catastrophic situations. Perhaps the most critical disorder in which to address this limitation is specific phobia, particularly the environmental and situational subtypes. Many of the most common phobias within these subtypes involve scenarios whose consequences could be considered improbable catastrophes, including drowning, being caught in a natural disaster, or falling from a high height (APA, 2013). Of course, these fears could perhaps be more parsimoniously explainedas evolutionary salient threats (Seligman, 1971), a categorization which helps explain the selectivity of specific phobia more generally. Nonetheless, SIC could be a more specific factor that pertains to both environmental and

situational phobias and OCD, which is line with findings showing that OCD co-occurs with these SP subtypes most frequently (Park et al., 2013).

Etiological Implications

Although data from this dissertation cannot be used to definitely identify the mechanism contributing the development of SIC, I believe there is sufficient evidence to tentatively concludethat this sensitivity arises through a distinct, two-step process.

First, I propose that OCD confers a specific tendency to overestimate the likelihood of improbable outcomes. This difficulty may manifest as an inability to achieve complete certainty(i.e., doubt), an over-reliance on possibilities relative to sensory information (i.e., inferential confusion) belief in power of non-physical forces (i.e. magical thinking, thought-action fusion), or reduced confidence in one's perceptions of reality (i.e., reduced cognitive confidence). Regardless of the particular trait mediating it, this distorted perception of improbable threat likelihood appears to possess three specific features. First, it is *pervasive* across situations and consequences. This feature is consistent with the finding that OCD predicted heightened expectancy of improbable threat independent of the outcome's cost (i.e., threat aversion ratings) and threat modality (i.e., shock-related vs. disgust-related), and with behavioral and subjective indicators of doubt emerging even in situations involving benign or absent consequences (Fear &Healy, 1997; Hermans et al., 2008). Second, this overestimation of improbable threat likelihood will usually be *slight*. This feature is consistent with OCD symptoms predicting significant

but relatively mild increases in improbable threat expectancy in both the current studies (see Figures 3.2 and 4.3) and past studies (e.g., Moritz & Jelinek, 2009) and with most OCD patients possessing intact insight into the senseless of their symptoms (e.g., Foa & Kozak, 1995; Marazziti et al., 2002; Kishore et al., 2004). Finally, I contend that this slight, but pervasive overestimation of improbable threat likelihood is fairly unique to OCD, consistent with improbable threat expectancy effects remaining significant when controlling for trait anxiety (studies 1 and 2), not generalizing to other anxiety symptoms (study 3), and being uniquely elevated among OCD patients relative to those with other anxiety disorders (see Chapter 1, Section 1.5).

Next, I propose that this slight, specific, and pervasive tendency to overestimate improbable event likelihoods may allow remote possibilities with higher subjective costs to become increasingly more likely triggers of obsessive thinking and compulsive behavior. Said another way, the tendency of OCD patients to overestimate improbable possibilities keeps fear ofhighly unlikely outcomes yoked to one's perceptions of their costs, allowing such events to trigger distress and avoidance when paired with a sufficiently severe consequence. Support for this step comes from the observed linear relationship between perceived threat aversion and avoidance of improbable threats among those high but not low in OCD symptoms (see figures 3.4 and 4.4). This data suggests that individuals with higher OCD symptoms continued to consider the possibility of electric shock even when its chance was remote, allowing individual differences in threat aversion to remain relevant in their approach-

avoidance calculus for improbable threats.

This second step helps account for the phenomenological observation that those with OCD only fear *certain* improbable threats. Specifically, this step predicts that events with high *objective* costs will be the most likely triggers of OCD, as they will most easily elicit the high *subjective* costs necessary for translating the latent overestimation of improbable event likelihoods into manifest symptoms. This facet is consistent with most feared consequences in OCD being veridical catastrophes (e.g., catching HIV from a doorknob, going to hell, stabbing a family member), but still leaves open the possibility that outcomes with *lower* objective costs can elicit OCD symptoms if the individual possesses additional cost-related distortions that causethese situations to be perceived as *subjectively* catastrophic. This accounts for why some OCD- relevant consequences involve lower objective costs (e.g., yelling profanities in church, possessing an abnormality with appearance), but suggests that individuals fearing these outcomes must possess *additional* cost-related distortions that result in them being perceived as subjectively severe. Interestingly, the presentations associated with these consequences (somatic OCD, sexual OCD, hoarding) are often more common among patients with lower insight (Storchet al., 2008; Catapano et al., 2010; though see Matsunaga et al., 2002), perhaps indicating that these outcomes only trigger manifest symptoms among individual whose threat-related perceptions deviate significantly from reality.

In addition, step two is consistent with past data linking OCD to

certain cost-related distortions. On one hand, a number of traits conceptualized as producing inflated perceptions ofcosts (e.g., intolerance of uncertainty, inflated responsibility, perfectionism) have been repeatedly implicated in OCD. These traits may increase the subjective aversion to improbable events involving veridical catastrophes, or render improbable, less severe events subjectively catastrophic, thereby explaining why these factors still correlate with levels of OCD pathology. However, because objective catastrophes are sufficient to trigger distress on their own, cost- related distortions should not be *necessary* for OCD behaviors, perhaps explaining why links between OCD and these factors are more tenuous (see Chapter 1, Section 1.5). Moreover, because cost-related distortions are incapable of eliciting OCD in the absence of the (initial) probability-based distortion, they should also not be distinguishing feature of the illness. This supposition is consistent with cost-based distortions being more generalized features of anxietypathology rather than specific indicators of OCD.

Application of mechanism to other threats

To illustrate how the above mechanism could produce a sensitivity to improbable catastrophes specifically, I would like to briefly demonstrate how this process applies to consequence with different costs and probabilities. First, consider the choice to avoid the OCD- relevant improbable catastrophe—re-checking the stove to prevent a fire—outlined in chapter 1, where checking has an objective cost of -1 and a probability of 1, and losing one's house to a fire (given that one checked) an objective cost of -100,000

and an objective probability of .000001. Although not checking is initially the favored option (i.e., [Checking: -1 x 1 = -1] < [Not Checking: -100,000 x .000001 = 0.1]), a small overestimation of threat probability (i.e., p = .00001 rather than p = .00001) would be sufficient to tip the balance in favor of checking because the consequence is objectively severe (i.e., [-1 x 1] 1 > -10[-100,000 x .0001]). Additional cost-based inflations could also increase the outcome's overall aversive value (e.g., the person could be bothered by the idea that they would be *responsible* for the subsequent fire); however, these additional distortions are not necessary and would only become relevant in caseswhere the perceived probability appraisal is elevated significantly above zero.

Next, apply this mechanism to the same scenario but substitute the consequence with a less severe (but still improbable) outcome: Ruining a new gas stove (e.g., -10). In this case, thesame slight overestimation of event probability would be insufficient to motivate checking behavior. Indeed, only a relatively substantial overestimate of the event's likelihood (i.e., appraising it as .10 or greater), perhaps in tandem with a separate cost-related overestimation, could result in checking becoming preferable. This is consistent with OCD sometimes involving improbable, less severe consequences, but with such outcomes being less typical.

Next, consider a similar checking-related scenario involving a consequence with a higherprobability and lower cost: Receiving a higher electric bill after forgetting to turn off a light. Because this outcome is at least

reasonably likely (e.g., probability = .20), the mechanism would predict that the specific tendency to overestimate *improbable threats* would not be relevant and thus no probability-based overestimation would occur. Moreover, while the person with OCD could find a slightly higher electric bill more aversive as the result of peripheral cost-related distortions (e.g., high perfectionistic standards), such a distortion is unlikely to ubiquitous acrossOCD cases (e.g., Martinelli et al., 2014) and is probably also shared with other anxiety disorders (e.g., Limburg et al., 2017). This suggests that this situation, at best, would not evoke increased checking behavior specifically for those with OCD.

Finally, while consequences with high probabilities and high costs are undoubtedly distressing, such distress would also be clearly adaptive given the veridical danger of the outcome. For instance, if one does not remember turning off the stove and sees smoke coming from their house, checking is clearly the necessary response and would not be considered an OCD compulsion. Indeed, OCD patients are just as cautious with their choices as healthy and anxious controls when facing theoretical consequences involving high probabilities of severe harm (e.g., Foa et al., 2002). This evidence coheres with the face-valid assertion those with OCDshould respond normatively in scenarios involving legitimate threats.

Integration of SIC with current etiological models of OCD

To conclude this section, I would like to briefly discuss how this proposed two-step mechanism could be integrated with the claims of OCD's major etiological theories (see Chapter1, Section 1.1 for a review of these

theories). Turning first to CAMs, a point of commonality is that OCD symptoms arise through an overestimation of threat. Moreover, both my model and CAMs contend that these threat-based distortions may look different across common OCD subtypes (e.g., involve different traits or belief structures), which critical in accounting for the phenomenological heterogeneity of OCD.

The major point of departure between my model and CAMs is the *type* of threat-based distortion proposed: While my model places greater importance on traits that should result in overestimates of threat *probability,* those traits typically implicated in CAMs are more linked to overestimations of *cost.* These include beliefs about inflated responsibility, intolerance of uncertainty, perfectionism and others (OCCWG, 2003)—all of which generally pertain to cost- based rather than probability-based overestimations of threat (see Chapter 1, Section 1.5). As reviewed earlier, the issue with explaining OCD symptoms via cost-based distortions is that these overestimates are a) not specific to OCD (e.g., Tolin et al., 2001), and b) not specific to catastrophic consequences. In other words, cost-based distortions cannot explain why those with OCD fear improbable catastrophes specifically or why fears of such events arise mainly in OCD. Nonetheless, my model still maintains that cost-based distortions can exacerbate OCD symptoms by augmenting the subjective severity of feared consequences, consistent with the empirically- supported role of such beliefs in OCD (e.g., Myers et al., 2008).

Unlike CAMs, The IBA model (O'Connor, 2005) proposes that OCD symptoms arise primarily through a probability-based distortion, which is a

clear point of convergence with my model. Specifically, the IBA model contends that OCD symptoms originate with an initial doubting inference that results in a theoretical possibility (e.g., “Maybe my hands are dirty”) being treated as an actual probability. Although the IBA model attributes this doubting inference to failure in a reasoning process (inferential confusion) rather than an overestimation of improbable threat likelihood (as in my model), the end result is the same: The individual with OCD assigns a remote possibility an actual probability, allowing it to generate obsessive thinking and motivate compulsive behavior.

Where my proposal diverges from the IBA model is in the second step: The IBA model does not attempt to explain why this original probability-based overestimation (or reasoning error) only leads to certain feared consequences, while my model proposes that this distortion only become problematic when paired with a sufficiently aversive outcome. Accordingly, the IBA model cannot explain why only certain possibilities trigger OCD symptoms. Moreover, the IBA model fails to integrate the surfeit of empirical evidence linking OCD to cost-based distortions that have nothing to do with probability-based reasoning errors (OCCWG, 2003; Myers et al., 2008), which the second step of my model attempts to integrate.

The claims of Szechtman and Woody’s (2004) Security-Motivation-System (SMS) Theory seem to diverge more significantly from both model and from IBA and CAMs. Specifically, SMS theory conceptualizes OCD as a pathology of *stopping* rather than *starting*,

proposing that while all humans possess an SMS that responds to subtle and often hidden indications of danger, those with OCD lack the ability to terminate this threat system. As noted by other authors, the difficulty with integrating the SMS proposal with existing OCD theories isthat its claims are difficult to operationalize and falsify (Taylor, McKay, & Abramowitz, 2005). For instance, the claim that the SMS is a universal human threat system implies that the *starting* mechanism of OCD symptoms should be similar across affected and unaffected persons; however, it is not clear how the existence of the SMS could be shown empirically (Taylor et al., 2005). A more specific issue with comparing SMS theory with my proposal is that the PIG paradigm is not designed to differentiate between abnormalities in starting versus stopping mechanisms: Threat responses are collected on a momentary as opposed to on-going basis (i.e., single button presses, startle to brief probes), so it is unknown whether those with elevated OCD symptoms in the current studies would have experienced more distress when disengaging from, for instance, a more protracted avoidance choice (see Hinds et al., 2012, for an example of such a paradigm).

Perhaps the only claim of the SMS that my data can speak to is the nature of the threat response mediating the mechanisms contributing to OCD symptoms. Specifically, Szetchtman and Woody (2004) propose that the SMS operates in a largely *non-cognitive* manner, thereby emphasizing the importance of *subjective* feelings (e.g., anxiety, disgust, not-rightness) and

physiological responses relative to cognitively-based beliefs and/or threat appraisals. Data frommy studies indicate that those with elevated OCD symptoms may indeed exhibit heightened subjective feelings (i.e., subjective anxiety ratings) and physiological responses (i.e., startle) to the sort of subtle indications of danger (i.e., cues that are highly dissimilar from danger) that the SMS proposes. However, much more consistent evidence was gleaned for *beliefs* about the riskof improbable threat (i.e. threat expectancy ratings) in my studies, which is not the pattern one would be expect if such responses were the secondary outlet of symptom manifestations as claimed by the SMS theory.

Finally, regarding Gillian's habit hypothesis (Gillan, & Sahakian, 2015), it is clear that there is marked divergence from my proposed model. Specifically, Gillan maintains that compulsions—which are excessively engrained habits—are the primary driver of OCD symptoms, while obsessions are merely post-hoc justification for compulsive behavior. In contrast, my model, as well as traditional OCD theories, maintain that it is the misappraisal of the feared consequence associated with obsessional content that produces discomfort, which in turns motivates the desire for compulsive avoidance. While Gillan presents compelling experimental (Gillan et al., 2011; Gillan et al., 2014) and neurobiological (Graybiel, 1997) evidence for the proposition that OCD involves excessive habit formation, a major shortcoming of her proposal is that it cannot explain why this abnormality leads to only certain OCD presentations. More specifically,

there are many actions that could theoretically become habitual, and there are many post-hoc justifications one could make to explain their odd, habitual behaviors; therefore, if excessive habit formation is the sole contributor to OCD, one would expect a seemingly endless variety of compulsions (i.e. habitual actions) and obsessions (i.e. post-hoc justifications) to be associated with the disorder.

Nonetheless, Gillan's theory does bring attention to some important phenomenological features of OCD that are left unaccounted for by both my model and others. Chief among these is the fact that a non-trivial proportion of those with OCD are unable to identify an explicit feared consequence driving their compulsive behavior (Starcevic et al., 2011). This phenomenological subtype appears to be especially prevalent in cases of child OCD, as Swedo et al. (1989) reports that virtually all young children with OCD in their sample were unable to identify a specific reason for their compulsions. Perhaps more problematic is the fact that most patients with symmetry/ordering symptoms, which are the third-most common OCD presentation (Rasmussen & Eisen, 1992; Foa & Koza, 1995), report that this preoccupation is driven by an internal feeling of 'not-rightness' rather than a fear of an explicit consequence (Summerfeldt et al., 2015). Thus, theories that base their understanding of OCD symptoms on a misappraisal of feared consequences must explain how the disorder develops in those reporting no explicit consequenceat all.

Although the data collected for this dissertation is far from capable of addressing this issue, one tentative explanation is that SIC preferentially

surfaces in an unconscious and behavioral manner early in life. Moreover, this early manifestation of SIC may primarily gear children toward maintaining order and stability in their environment, which as pointed out Szechtman and Woody (2004) could be an adaptive way to prevent subtle and hidden threats to survival (i.e., improbable catastrophes). In support, symmetry/ordering is the presentation the most OCD patients recall developing first (Pinto et al., 2008), and is typically the first sign of dysfunction to parents of OCD children (Radomsky & Rachman, 2004); however, this tendency toward order could also manifest as rigidly repeating other everyday actions (e.g., handwashing), which is necessary for explaining why other OCD presentations also develop early on in childhood. Regardless of the particular OCD symptom that arises, conscious manifestations of SIC may not appear until later on in development. For instance, explicit beliefs surrounding the possibility of improbable catastrophes may not come online until more abstract reasoning processes have sufficiently developed. Moreover, repetitive actions gear toward environmental stability may represent a precautionary strategy for mitigating potential danger (i.e., a *better- safe-than-sorry* strategy; Smeets, de Jong, & Mayer, 2000), rather than a response to anxiety, which does not arise until later. In support, Zohar et al. (1997) found that repetitive, OCD-like behaviors in children only became associated with anxiety in later adolescence, and experimental evidence has repeatedly shown that engaging in safety behaviors can paradoxically produce increases in anxious feelings (e.g., van den Hout et al., 2014; Engehard, van Uijen, van Seters, &Velu, 2015; van Uijen & Engelhard,

2018).

Of course, this particular developmental ordering of SIC-mediated threat responses would only apply to those with early-onset OCD: The majority of those who develop OCD in their early 20s (Delorme et al., 2005) may still first experience SIC via cognitive intrusions around a specific possibility (e.g., "what if I stab my infant?"), which matches phenomenological rreports in a variety of case studies and forms the basis for most etiological theories of OCD (OCCWG, 2003). Regardless, this speculative proposition clearly requires a great deal more research to validate, in particular when it comes to whether SIC manifests differently in children versus adults or early-onset cases versus later-onset cases. Similarly, it remains unclear at this point how presentations involving symmetry/ordering figure into the broader SIC theory, which is an issue that will need to be addressed more extensively in future work.

Clinical Implications

OCD Assessment

There are two major challenges faced by current OCD assessment tools that an experimental measure of SIC could help address. The first challenge is that the course of OCD can be quite variable: Although most cases are chronic (Perugi et al.,1998), many individuals experience full or partial remission of symptoms over time (Angst et al., 2004), while as many as 10% experience gradually worsening symptoms (Goodwin et al., 1969). Moreover, although those prone to a chronic course sometimes possess certain clinical features (e.g., more severe OCD symptoms, earlier age of onset; Perugi et al., 1998),

these features are associated with onlymarginally higher odds of chronicity, which therefore remains a difficult phenomenon to predict. The inability to adequately discriminate between patients with transient versus chronic OCD is also problematic: Clinical resources (e.g., clinician proximity and availability) and patient resources (e.g., money) are often scarce (Marques et al., 2010), and should thus ideally be devoted to a problem that is less likely to remit naturally over time.

Results from study three illustrate how measures of SIC could be helpful for addressing this particular clinical barrier. Based on the distribution of OCI-R scores, a significant number ofparticipants reported high enough levels of OCD-related distress or impairment in their first semester of college to potentially garner some degree of clinical attention. Treating all individuals with these elevations, however, would in reality be a woefully inefficient use of resources, as many of them would ultimately experience a natural decrease in OCD symptoms bytheir second semester. Moreover, identification of students that would experience this decrease was only partially clarified using the OCD assessment tool (i.e., the OCI-R) used in this study, as shown by the fact that close to 85% of the variance in future OCI-R scores remained unexplainedby OCI-R scores at baseline. Accordingly, the additional variance explained by improbable threat response in the PIG paradigm could help disambiguate individuals with temporary, perhaps stress-induced OCD elevations versus those with a more intractable issue. In this way, instruments measuring SIC could perhaps help providers with limited clinical resources better decide

which patients with similar levels of OCD symptoms are in more need of immediate intervention.

A second, related challenge faced by current OCD assessment methods is the inability to identify premorbid risk for OCD. As is the case for all mental illnesses, there is currently no objective test capable of accurately detecting OCD susceptibility in currently unaffected individuals (Cuthbert & Insel, 2013). As a result, OCD cannot be identified (or technically even diagnosed) until the individual has experienced some clinically significant degree of distress or impairment in daily living, during which time the initially willful decision to avoid a potential consequence could translate into a more irresistible and compulsive habit (Hyman & Pedrick, 2009; Denys, 2011). Thus, identifying OCD-relevant markers that exist prior to and independent of OCD-related distress could be an immensely useful first step in preventing the compulsive cycle of OCD from beginning in at-risk individuals.

Arguably, results from study three are more consistent with SIC being a vulnerability marker than a correlate of OCD, as responses to improbable, highly aversive threat strongly predicted future, but not concurrent OCI-R scores. However, as discussed in Chapter 5, Section 5.4, this data alone cannot definitively implicate SIC as a premorbid vulnerability marker of OCD. For instance, the stress of the first semester of college could have triggered the development of SIC among those with higher but not lower levels of OCD, thereby allowing the sensitivity to act as a useful predictor of OCD symptom maintenance but perhaps not a pre-stressor indicator of future OCD. Moreover,

even though SIC was able to strongly predict future OCD symptoms, it is unclear whether its predicted variance is redundant with that of other, more economical measures of OCD risk. For instance, it could be the case that SIC predicts small or even significant variance in future OCD symptoms after controlling for relevant demographics factors like gender, age-of-onset, and marital status (Fontenelle & Hasler, 2008) or broad psychological factors like general negative affect (Grisham et al., 2011).

Although more research is clearly needed to establish SIC as a useful marker of vulnerability or maintenance, there are two aspects of the present results that are particularly encouraging in regard to the sensitivity's potential clinical translation. First, the consistent and strongest effects in all three studies were with behavioral measures (i.e., avoidance, threat expectancy) as opposed to psychophysiological ones (i.e., startle EMG). Although this does not rule out the possibility that other types of psychophysiological measures (e.g., skin conductance, EEG) could do a better job of identifying those with persistence OCD symptoms, the fact that positive effects with fairly non-invasive behavioral tools is a promising sign for clinical translation. Second, and relatedly, predictive effects with this these behavioral measures were quite strong. In the third study, between 7 – 10% of additional variance in future OCD symptoms was predicted by behavioral responses to improbable threat. When considering only participants who were highly averse to threat, this increase in predictive accuracy was even greater: 15.6% ofthe variance in future OCD symptoms was explained by anxiety to improbable threat and

19.9% by avoidance of improbable threat. It is unknown whether this degree of predictive accuracy will be replicated in larger and longer study, or whether it would outweigh the practical cost of implementing the PIG in a particular OCD clinic; however, the strength of this effect is still a highly encouraging albeit preliminary indicator of this task's potential clinical utility for identifying OCD susceptibility.

OCD Treatment

Regarding treatment implications, perhaps the most useful application of SIC is to inform a more unified and simplified type of OCD intervention. OCD is known to shift over timefrom one type of presentation to another (Rettew et al., 1992), potentially undoing much of the progress that was achieved by addressing a particular set of OCD symptoms. Moreover, over half of OCD patients express four or more distinct subtypes (Ruscio et al., 2011), which presents as a major challenge for clinicians attempting to establish, order, and treat multiple symptom hierarchies in EX/RP. Accordingly, interventions aimed at addressing a more fundamental sensitivity like SIC could be tremendously beneficial for efficiently treating patients prone to a wide variety of OCD manifestations.

There are two ways that SIC could be implemented to help unify extant OCD interventions for treatment of multiple subtypes. First, existing CBT protocols could be adapted to incorporate SIC as a secondary and adjunctive treatment target. For instance, clinicians could make patients aware of SIC as a general bias contributing to their various symptom manifestations, perhaps

affording them a more coherent and normalizing account of what are often perceived as bizarre or shameful concerns (Weingarden & Renshaw, 2015). Knowledge of this underlying predilection to fear improbable catastrophes could also help patients more effectively cope with the genesis of new intrusive thoughts. For instance, suddenly having a novel, fleeting urge to stab one's child could be highly distressing, unexpected, and demoralizing for a patient whose OCD had previously been confined to contamination. However, appraising this thought as merely a different manifestation of an existing sensitivity to improbable catastrophes could help normalize its presence and make it less likely to trigger the sort of aggressive thought suppression that is believed to paradoxically increase the frequency and intensity of obsessive thoughts (Smàri & Hòlmsteinsson, 2001; Tolin, Abramowitz, Przeworski, & Foa, 2002; though see Janeck & Calamari, 1999).

The second way to incorporate SIC into OCD treatment is to make the process a more central component of an existing evidence-based intervention like EX/RP. In this option, the overarching goal of treatment would be to address the underlying tendency to fear and avoid improbable catastrophes, rather than attempting to reduce different types of obsessions and compulsions in a piecemeal fashion. For instance, rather than composing separate symptom hierarchies categorized by OCD subtype, one general hierarchy could be made that is ordered based on the perceived probability and aversiveness of each feared consequence. Ideally, proceeding through this hierarchy would allow the patient to become gradually more aware of their tendency to overestimate the

risk of improbable catastrophes *in general*, which could subsequently be applied to any new or untreated obsession that had gone previously unaddressed.

This unified treatment could also be tailored to address the overestimation of improbable threat likelihood that putatively contributing to SIC. Indeed, Inference-Based Therapy (IBT; O'Connor et al., 2005) addresses a specific probability-based distortion—excessive doubt—by teaching patients OCD patient to rely more on *sensory information* (e.g., "I felt the door is locked, therefore it is locked") as opposed to *possibility-based information* (e.g., "Maybe I am remembering a different time I locked the door"). Results from IBT have thus far been highly encouraging, showing equivalent efficacy to EX/RP in its two extant clinical trials (O'Connor etal., 2005; Visser et al., 2015), and even better efficacy among patients with very poor insight (Visser et al., 2015). Using IBT as a guide, other complementary modules could also be developed to address overestimations of improbable threat likelihood that surface through other traits (e.g., magical thinking, sympathetic magic). Additionally, extant OCD treatments could also be adapted to address inflated perceptions of threat-related *costs*, which while not conceived as a necessary component of SIC, could nonetheless render improbable catastrophes more aversive and thus more difficult to face during treatment. Indeed, clinicians have long noted that many OCD patients with intact perceptions of threat probability may continue to exhibit symptoms if they possess (additional) overestimations in their feared consequences' costs (Carr, 1974; Van Oppen &

Artnz, 1995), making such distortions an important additional focus of treatment.

Conclusions

The purpose of this dissertation was to outline and test the theory that OCD is characterized by an underlying sensitivity to improbable catastrophes (SIC). The presence of this sensitivity is implied by the ubiquity of feared outcomes across diverse forms of OCD that involve both very low likelihoods and very high subjective costs. Moreover, other anxiety- related conditions typically involve feared consequences involving different cost and probability combinations, suggesting SIC uniquely contributes to the development of OCD. However, no studies to date had explicitly examined relations between OCD symptoms and responses to threats of varying probability and subjective aversiveness to confirm that those elevated on such ymptoms actually respond most anxiously to improbable, catastrophic outcomes.

Overall, results offer strong initial support for the theory that OCD involves a heightenedsensitivity to improbable catastrophes. In the first study, those with elevated OCD symptoms showed greatest avoidance when threats were improbable and highly aversive, as well as greater startle, avoidance, and expectancy of improbable threats more generally. These results were largely replicated in study two, where those higher on OCD symptoms demonstrated heightened threat expectancy to improbable (but not more probable) threat involving both harmful and disgust-related consequences, as well as greater avoidance of improbable, highly aversive threatsinvolving harm. Study three

further extended these results by showing that first-semester students who were expectant, anxious, and avoidant of improbable threat reported higher levels OCD symptoms their second semester, with indices of anxious reactivity to improbable outcomes (anxiety ratings, avoidance, startle responses) emerging as even stronger predictors of future OCD symptoms among those who found the experimental threat highly aversive. Thus, OCD symptoms were consistently associated with greater avoidance and (to a lesser extent) anxiety when threats most approximated improbable catastrophes, as well as greater tendencies to overestimate the likelihood of improbable threat independent of their perceived aversiveness.

Together, these results implicate a sensitivity to improbable catastrophes as a novel pathogenic marker of OCD, which may be particularly evident through avoidance behavior, and perhaps driven by the pairing of a more general proclivity to overestimate the likelihood of improbable events in a situation bearing a subjectively costly consequence. Future research should build upon these findings in clinical samples consisting of patients with both different OCD presentations and other anxiety diagnoses, which would be instrumental in establishing SIC as a sensitive and specific marker of OCD. Moreover, altered version of the experimental paradigm used to assess SIC, as well as measurement of other OCD-relevant constructs, could further clarify whether the purported sensitivity to improbable catastrophes is the result of elevations in traits believed to inflate one's perception of risk for improbable events (e.g., proclivity to doubt). Ultimately, SIC and its associated

mechanisms could be useful for distinguishing between persistent and transient forms of OCD and for augmenting the ability of existing interventions to treat OCD patients exhibiting multiple symptom subtypes

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